transition
Moving to a smart future

Project Deliverable

Analysis of DSO Flexibility Markets

Scottish & Southern Electricity Networks

Origami
POWER OVER ENERGY

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1. INTRODUCTION

The purpose of this report is to look at DSO projects across the world and to identify the relevant international experience of flexibility markets. The findings of the report will be used to identify relevant projects, best practice and best value for money for validating SSEN's TRANSITION and LEO projects.

As governments across the world push for a reduction in carbon emissions and improved air quality in their respective countries, climate concerns have become the main driver for the decarbonisation of energy and as a result we already see the generation mix changing dramatically. As the capital cost of lower carbon renewable technologies reduces further, they are replacing older fossil generation. The transport sector is also under increased pressure to move away from using fossil fuels towards low emission vehicles and electric and hydrogen-fuelled vehicles are starting to become commonplace.

As the world moves towards decentralised generation (with less flexibility than the fossil fuel generation it replaces) it is recognised that electricity grids will require flexibility services. This will require support of energy storage, demand response and yet-to-be developed flexibility services markets. At present, power plants dominate flexibility options – see Figure1[1].

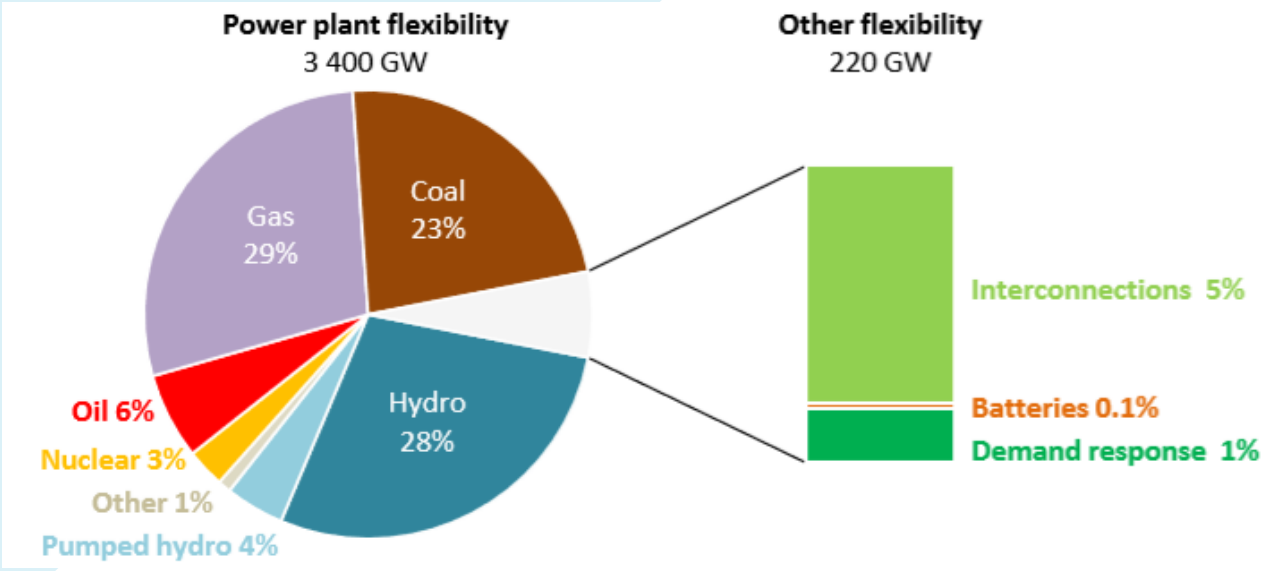

Figure 1 – Existing Global Flexibility Mix

[1] IEA World Energy Outlook 2018 | Special Focus on Electricity Page 302

This move to low carbon energy and transport has created scaremongering and quotes of the devastation that the imbalance and peaking effect of these will cause the electricity grids. However, it is now widely accepted that with appropriate planning and application of smart technologies and solutions these perceived problems can be avoided. National Grid confirmed this in a recent "myth buster" article[2], stating that most of these issues can be avoided using smart technologies. It is, however, recognised that all network companies will have to change their processes and procedures to accommodate these new generation technologies to be able to keep the lights on. It is further recognised that flexibility services and new market models will be required to facilitate the move to a secure and dynamic grid of the future.

SSEN won funding from Ofgem's NIC 2017 competition for TRANSITION[3] which aims to de-risk and facilitate the transition from Distribution Network Operator (DNO) to Distribution System Operator (DSO) and help inform the marketplace. TRANSITION will be informed by the Energy Network Association's (ENA's) Open Networks Project and will build on the experience and learnings gained through other LCNF, NIC, and NIA projects, including Low Carbon London, CLASS, New Thames Valley Vision and ENTIRE. Ofgem's direction states that TRANSITION must also coordinate with Western Power Distribution's EFFS and SPEN's FUSION project to avoid unnecessary duplication of effort and to maximise learnings for the industry.

SSEN are also leading on an UK Industrial Strategy funded project called Local Energy Oxfordshire (LEO)[4]. This project has received funding from Innovate UK to develop a new model for the way in which local energy systems in Oxfordshire are managed and measured. The system will help test new markets, inform investment models and, assess the benefits of flexibility to the energy system.

There are already many pilot and innovative projects taking place across GB and Europe, where companies and their partners are developing and trialling solutions and flexibility services to facilitate the connection of additional DERs and demand. This report looks at projects in Europe and worldwide to identify relevant international of DSO flexibility markets relating to the objectives of TRANSITION.

[2] National Grid Myth Buster Publication – August 2017

[3] www.ofgem.gov.uk/system/files/docs/2018/10/transition_-_direction_amended_09_2018.pdf

[4] http://news.ssen.co.uk/news/all-articles/2019/april/ssen-announces-ground-breaking-innovation-project-to-inform-the-future-of-local-energy-systems/

2. KEY FINDINGS AND SUMMARY

- Most countries reviewed in this report are in the process of transitioning away from a reliance on fossil generation to lower carbon generation technologies, such as wind and solar, and the significant cost reductions for those technologies in recent years has resulted in their deployment at scale in some of the countries reviewed;
- The majority of countries report a move towards using more distributed generation, with demand side management and energy storage supporting the security of their grids. However, most are at the pilot or innovation funded project stage and not Business as Usual (BaU). The exceptions are GB, Australia and North America where there are early signs of acceptance to business as usual solutions;
- Internationally, Government energy policy in most countries recognise that flexibility services are required to maximise the benefits of a secure and balanced grid, lower the cost to the end customer and to make savings from deferred or avoided reinforcement. However, the development and use of flexibility services are still in their infancy and most countries continue to rely on traditional balancing services options;
- Many countries report concerns around the level of market understanding present in the regulator and the speed required to effect the changes to policies and processes to make this happen. A recent survey by KPMG[5] stated that the major challenge for the "new" DSO in Europe is that regulation does not move fast enough and there is a lack of understanding by the regulators to develop the tools to maximise the benefits;
- A matrix was developed to determine the relative ranking of countries across a variety of factors, including: demand side management, flexibility services piloting and BaU and the level of renewables penetration status; California, GB, Australia and Texas perform very well internationally in this matrix.
- The analysis indicates that Europe's regulator and network companies are leading the international charge with a widespread acceptance of the challenges that lie ahead. There is also recognition of the opportunities that will arise from a low carbon world with a continued high level of investment in innovative trials and projects. This includes the development and implementation of a new pan-European balancing product that involves the trading of certain

[5] KPMG/ Vlerick Business School "Outlook on the European DSO Landscape 2020

balancing services across Europe through the Trans European Replacement Reserve Exchange project;

- Australia and the coastal states of North America are very active, and regulators are encouraging the use of the low carbon solutions, however flexibility services are still in its infancy;
- Asian countries are turning to renewable generation and starting to look at pilot projects to solve their individual issues and how to maximise the challenges and opportunities;
- Several distributed ledger (blockchain) projects are being rolled out and South Korea appears to be leading the charge in this area;
- Several GB-based companies are now exporting their expertise, including: Moixa Technologies (battery and domestic energy management system, Japan), Smarter Grid Solutions (Active Network Management, North America), Tempus Energy (domestic price matching offer, Australia), Electron (Blockchain Flexibility Trading Platform, South Korea), and EA Technology (experience from GB innovation projects, internationally).

3. THE TRANSITION PROJECT

TRANSITION is looking at the implications of a properly functioning market in flexibility that enables flexibility providers to stack value across the various existing markets for flex services and for the DSO to evaluate how the use of flexibility can contribute to the efficient and economic operation of their infrastructure in a number of scenarios. The TRANSITION project proposes to cover new ground with the outputs informing the Energy Networks Association (ENA) Open Networks project (ON-P) in the following areas: design requirements for the flexibility platform; developing future roles and responsibilities within the marketplace, developing new market rules required for the trials, and implement and test the concept of the flexibility platform.

Workstream 3 of ON-P is developing a more detailed view of the required transition from DNO to DSO, including the impacts on existing organisation capabilities prior to the implementation of the DSO.

3.1 Main Deliverables of TRANSITION

The main deliverables of TRANSITION are detailed below.

TRANSITION aims to:

- accelerate and de-risk the transition from DNO to DSO, reducing uncertainty for customers and industry;
- provide a clear signal to the market that a new platform (or platforms) for market development will be in place and enable the growth of new potentially disruptive market models, products and services; and
- inform the appropriateness of competency assumptions for different DSO functions over various timescales.

TRANSITION will deliver:

- requirements for changes to industry data needs, exchanges and structures;
- an outline process for real-time monitoring and visibility of the network;
- learnings from the operation of the NMF Platform as a commercial tool and the consequences of interactions between MPs;
- an outline requirement specification for a Platform that is scalable and technology neutral;
- a comparison of market models under different network configurations; and
- recommendations on required changes to existing market rules and codes (such as OC6 of the grid code and the BSC).

TRANSITION will develop and demonstrate:

- NMF platform including enabling infrastructure, data exchanges and commercial arrangements;
- demonstrate and test potential solutions to inform further development of Open Networks market model options;
- identify cost, risk, and benefits of the market models proposed; and
- consult with a range of stakeholders to ensure the analysis is undertaken from a whole-system perspective.

(Source: TRANSITION Project final submission document - ref 2.1.8 pages 8,9)

3.2 TRANSITION Stages

TRANSITION will be completed in three stages:

- Phase 1 - design the solution for the Neutral Market Facilitator (NMF) and how it will interact with the DNO systems of today; develop the roles and responsibilities of market participants; develop simple rules to enable the delivery of selected services; and determine the location and requirements of a trial in Phase 2.
- Stage Gate (aligned with EFFS and FUSION) - determine whether it is still valuable to continue with TRANSITION and continue with Phase 2.
- Phase 2 – procure a technology solution to integrate the DNO systems and interact with the future market and conduct a wide scale trial to test the services, roles and rules and inform the Open Networks project.

To complete the first phase of the project, SSEN has partnered with the following companies:

- **CGI** with considerable knowledge of energy markets, smart grids, smart meters and system integration;
- **WS Atkins** with considerable expertise, knowledge of the network businesses and grids across the world; and
- **Origami** with considerable knowledge and experience of the GB electricity market and "Flexible Services" markets and platforms.

4. ELECTRICITY GRIDS AND THE NEED FOR EMBEDDED FLEXIBILITY

4.1 Electricity Grids

Traditional power systems throughout the world invariably follow the same pattern with a uni-directional flow of electricity from large centralised generation stations through transmission grids that move electricity from one region of the country to another. Within each region, the electricity is distributed to the end customer (domestic and non-domestic) at various voltages depending on electricity demand. This model is illustrated in Figure 2 below.

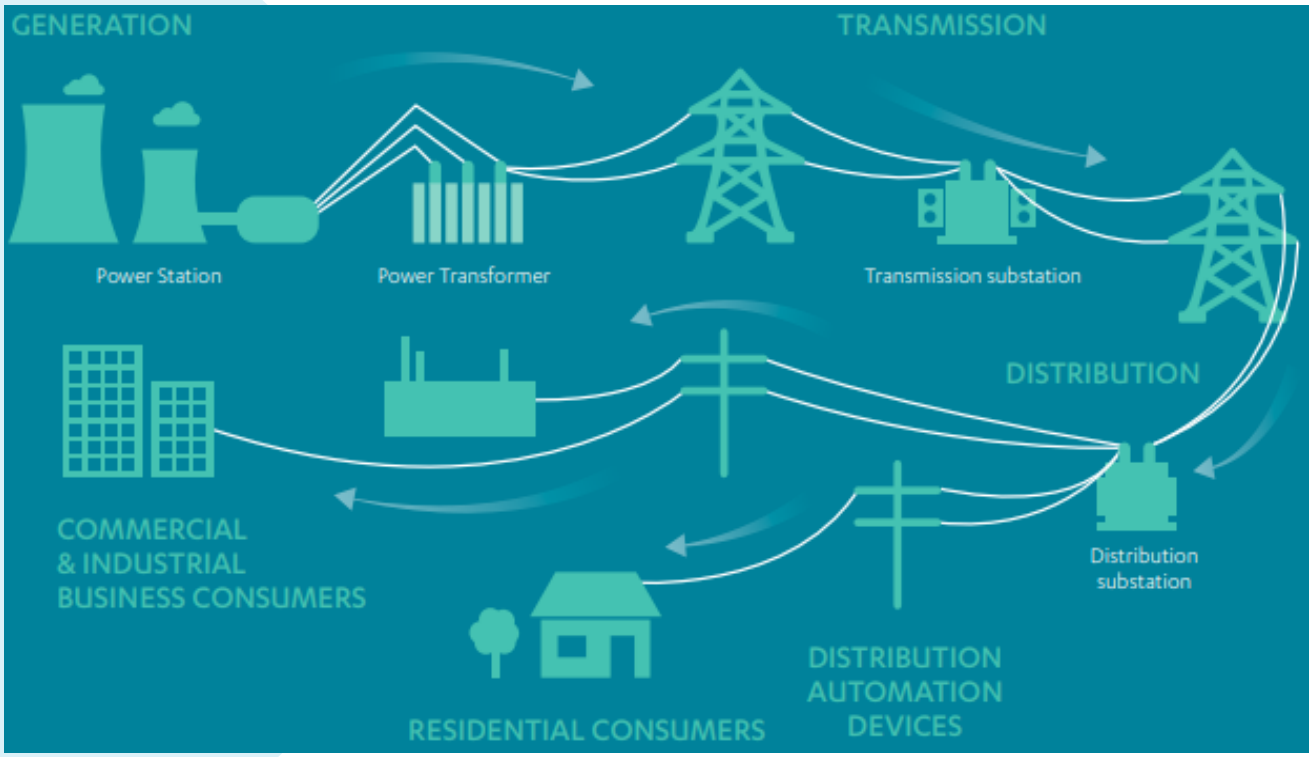

Figure 2 – Traditional Power System Uni-Directional Flow of Electricity [6]

The traditional power systems model is no longer valid as increasing amounts of new distributed (low carbon) generation is embedded in the distribution network. This creates significant variability in the level and direction of power flows which can cause issues related to capacity, services and balancing the system in real-time. New technologies are emerging at an ever-increasing pace and some, e.g. solar, are blurring the distinctions between suppliers and consumers of electricity as end customers start to manage their demand for electricity more actively. This model is illustrated in Figure 3.

[6] National Infrastructure Commission Report on Smart Power

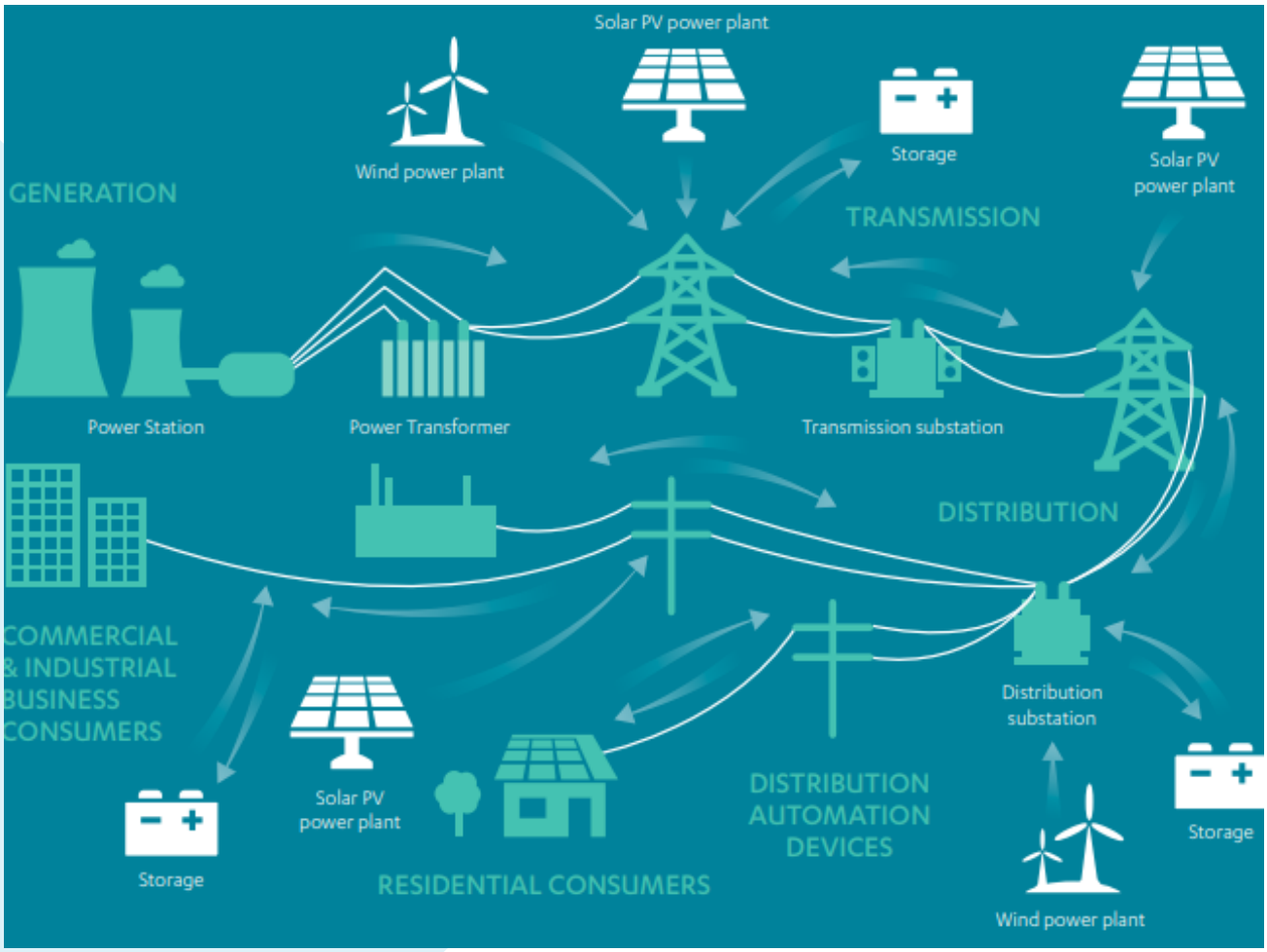

Figure 3 – Future Power System Multi-Directional Flow of Electricity[7]

4.2 General Overview of DNOs and DSOs in 2019

In 2019, DNOs and DSOs operate in substantially the same way, fulfilling the same function in a largely reactive network that makes little use of existing embedded flexibility[8]. The role varies from country to country, mainly due to variations in; national regulation, politics, ownership structure, climate and geography. This traditional role of DNOs and DSOs is to operate, maintain and develop the distribution network to ensure that electricity is delivered to end-users in a secure, reliable and efficient manner.

[7] National Infrastructure Commission Report on Smart Power

[8] Overview of Electricity Distribution in Europe Summary from Capgemini's 2008 European benchmarking survey

These organisations are DNOs in GB but are already called DSOs in Europe, although they fulfil the same role.

In the future, the role is expected to change and is summarised well in the following quotation from the European Commission DISTRIBUTION SYSTEM OPERATORS OBSERVATORY[9]:

"DSOs play a role in the efficient functioning of the European electricity markets, as they act as "entry gates" to retail markets in most EU countries (CEER 2013), potentially influencing the level of competition in this segment. They should therefore guarantee non-discriminatory access to the grid and provide system users with the information they need for efficient access to, including use of, the system. Lately however, the changes triggered by the increasing penetration of local renewable generation and by the emergence of demand response enabling solutions are calling for a reconsideration of the role of DSOs. DSOs will be increasingly required to perform more (pro-) active grid development, management and operation as these changes place new requirements on the grids in terms of operational security, while they offer at the same time more options for the DSOs to manage their grids in a more flexible and efficient way (van den Oosterkamp, et al. 2014). Research and debate are still open with respect to the new tasks, responsibilities and opportunities that are shaping up in the evolving power system (CEER 2015) (Eurelectric 2010) (Ruester, et al. 2013) (van den Oosterkamp, et al. 2014). These new tasks could in principle be performed by DSOs or they could be open to new and competing actors, in a market environment."

In summary, these roles are still evolving, and it is anticipated that TRANSITION will inform the development of DSOs and the associated market models required for the future of DNOs in GB.

4.3 The Need for Embedded Flexibility

Flexibility is defined as "the ability to modify generation and/or consumption patterns in reaction to an external signal (such as a change in price, or a message)."[10] Embedded System need for flexibility is flexibility connected directly to the distribution grid that could provide one or more flexibility services to support the grid, whether locally, regionally, or nationally.

[9] European Commission ESO DISTRIBUTION SYSTEM OPERATORS OBSERVATORY

[10] "Upgrading Our Energy System Smart Systems and Flexibility Plan" published by Ofgem in July 2017

4.3.1 System Need

The decarbonisation of electricity supply has replaced centralised flexible generation with less flexible and intermittent distributed generation. As the capacity and volume of distributed generation increases, the electricity grid will need to be more flexible and adaptable than it is today to maintain existing levels of reliability and security of transmission and distribution grids.

Further, the move from a reactive DNO to a proactive DSO will increase the need for embedded flexibility and introduce the opportunity for real (as opposed paper-based) peer-to-peer services. This change will have to consider flexibility from different market actors as summarised in Table 1, which recognise the existing SSEN CMZ product suite and has tighter timescales.

4.3.2 Flexibility Services

As illustrated in Table 1, embedded flexibility has multiple uses from self-balancing through to providing a range of revenue generating services. The range of services depends on the speed at which the flexibility can react and where flexibility is located on the system; this is summarised in Figure 4.

4.3.3 Flexibility versus Infrastructure Investment

Embedded flexibility can be used by the distribution company to defer or avoid investment in infrastructure but there is a natural tension in this relationship. The embedded flexibility provider seeks compensation for the benefit the flexibility provides whereas the distribution company is incentivised to invest in infrastructure and make a long-term risk-adjusted return. In the limit, this tension could result in the distribution company offering low levels of revenue to ensure investment in infrastructure.

In December 2018, the six GB DNOs responded to this challenge with the Flexibility Commitment[11]. The Flexibility Commitment clearly states that DNOs will "Openly test the market to compare relevant reinforcement and market flexibility solutions …" and "… to develop the forthcoming RIIO-2 price control framework to ensure that the financial incentives that network companies receive are fully aligned with the greater use of flexibility services and do not favour the building of new infrastructure where these services are more efficient.

[11] http://www.energynetworks.org/assets/files/ENA%20Flex%20Committment.pdf

Table 1 - The Uses of flexibility by Different Market Participants against notification timeframes

	Immediate	Short-Term	Medium-Term	Long-Term
Minimum Notice	Real-time	3 mins	Day Ahead	Week Ahead
Maximum Notice	3 mins	Day Ahead	Week Ahead	No limit
ESO	▪ Frequency Response services ▪ Intertrips	▪ Frequency Response services ▪ Intertrips ▪ Balancing Mechanism ▪ Ancillary Service delivery	▪ Ancillary Service auctions ▪ Ancillary Service delivery	▪ Ancillary Service auctions
DNO	▪ Immediate constraint management services	▪ Immediate constraint management ▪ Planned constraint management	▪ Planned constraint management delivery	▪ Planned constraint management delivery ▪ Defer or avoid capital expenditure
Supplier	▪ Wholesale Trading	▪ Imbalance management ▪ Balancing Mechanism ▪ Portfolio management ▪ Trading opportunities	▪ Portfolio management ▪ Trading opportunities	▪ Portfolio management ▪ Trading opportunities ▪ Constraint Management and Ancillary Services auctions
Aggregator	▪ Delivery of immediate services to ESO and DSO	▪ Balancing Mechanism ▪ Ancillary Service delivery	▪ Ancillary Service delivery ▪ Ancillary Service auctions	▪ Constraint Management and Ancillary Services auctions
Flexibility Provider	▪ Delivery of flexibility for immediate services to ESO, DNO and aggregator	▪ Ancillary Service delivery	▪ Ancillary Service delivery ▪ Ancillary Service auctions	▪ Constraint Management and Ancillary Services auctions
Consumers	▪ N/A	▪ Capacity and energy management ▪ Cost reduction ▪ Profile management	▪ Cost reduction ▪ Profile management	▪ N/A

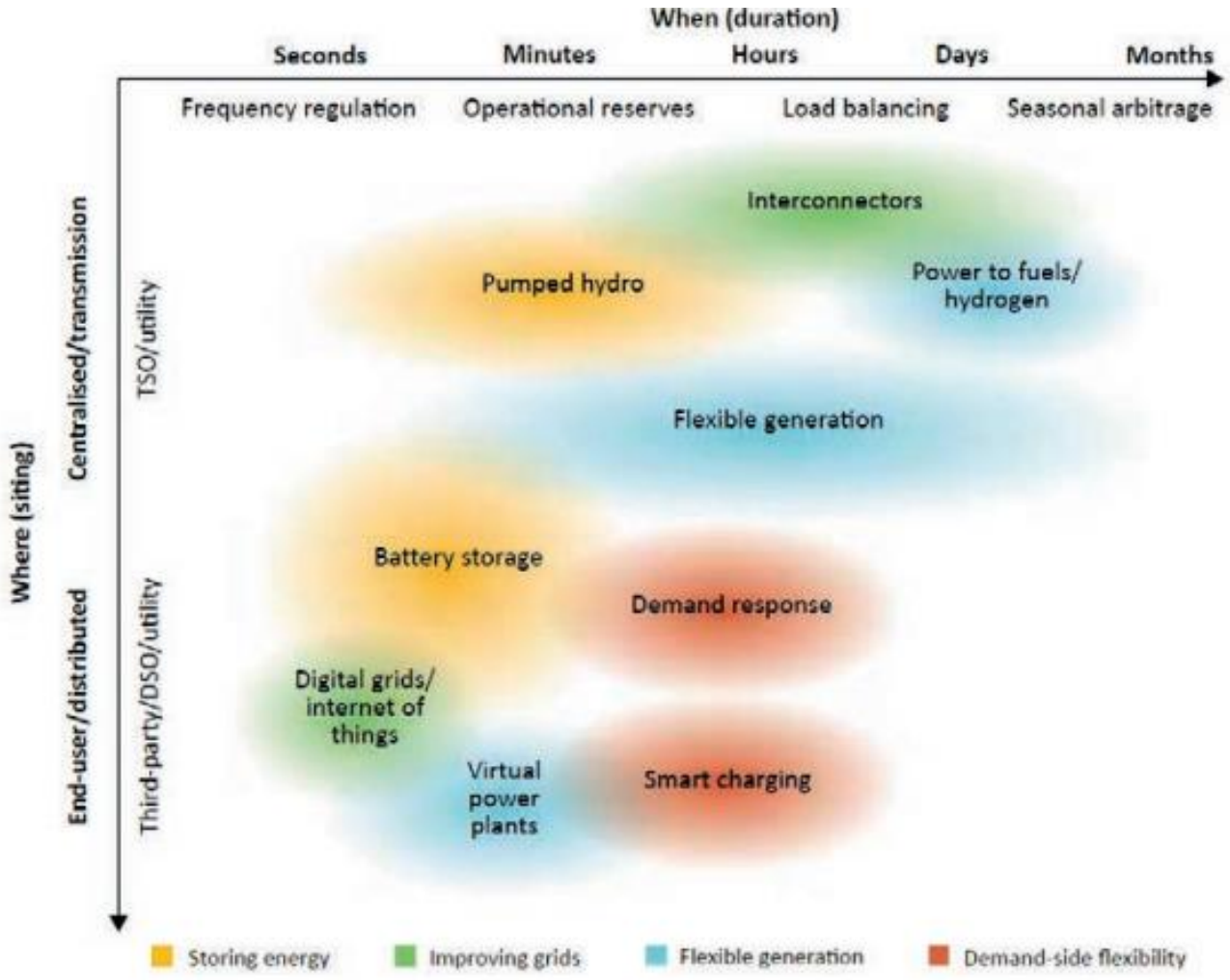

Figure 4 – Overview of Different Electricity System Flexibility Resources[12]

4.4 Value of Flexibility

The value offered in some markets is insufficient to attract investment in new capacity or to attract flexibility at the levels required. Without action by policy makers and regulators, this will put the security of power systems under greater pressure in the medium term.

The three main reasons for the difference are;

[12] China Power System Transformation; Assessing the benefit of optimised operations and advanced flexibility options

- flexibility provides a system-wide benefit, which also includes benefits that are not accessible to all market participants;
- each market participant values flexibility based on how it uses the flexibility; and
- some market participants obtain additional benefits as a consequence of purchasing flexibility to provide a single service at either a low cost or no cost.

This situation is summarised in Table 2 below. Unlocking more of the benefits / revenue streams could be transformative in encouraging new flexibility to come to market, whether new build or existing flexibility.

Table 2 - Beneficiaries of Flexibility[13]

Uses of Flexibility	Country	TO/ TNO	ESO	DNO / DSO	Supplier / Trader	Asset Owner	Customer
Reduced energy cost	X						X
Avoided energy consumption	X	X		X			X
Avoided distribution capacity	X	X		X		X	X
Avoided transmission capacity	X	X		X		X	X
Peer-to-Peer services income				X		X	X
Distribution services income				X	X	X	X
Transmission services income					X	X	X
Avoided / deferred infrastructure investment	X	X		X			
Avoided generation capacity / O&M costs	X			X		X	X
Distribution services				X	X	X	X
Transmission services				X	X	X	X
System balancing services			X		X	X	X
Avoided losses	X	X	X	X	X	X	X
Wholesale trading				X	X		
Market price reduction				X	X		X
Avoided generation capacity cost	X			X		X	
Avoided environmental costs	X	X	X	X	X	X	X

[13] "Valuing and Compensating Distributed Energy Resources in ERCOT," Brattle Group

5. FOCUS COUNTRIES AND KEY PROJECTS

This report has focussed on countries where the generation energy mix is moving away from fossil generation towards low carbon generation (predominantly wind and solar) and where demand patterns are changing through demand side changes including Electric Vehicles (EVs) and low carbon technology e.g. solar. These issues are creating specific challenges on grids. It is expected that these countries will implement flexibility services and new markets the quickest and we have therefore concentrated our efforts on Europe, Asia, Oceania and the Americas.

5.1 Europe

European countries and their electricity network companies are very active players in the transition to a low carbon future and, as countries move to more decentralised generation solutions, some of the challenges are already being experienced. The overall generation mix for Europe includes 40% renewables (including hydro) and this is expected to continue to rise.

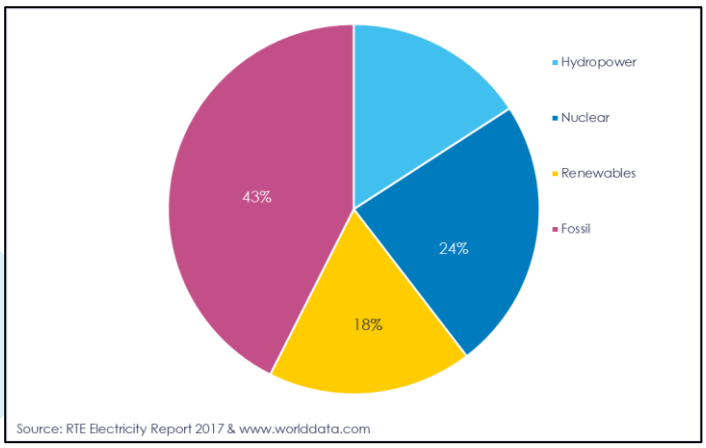

Figure 5 – Europe Energy Mix

Flexibility within Europe has traditionally come from fossil fuelled thermal generation, hydro, and interconnectors. However, the decrease in thermal generation and the increase of renewable generation (with its significant variability in the level and direction of power) has resulted in a much wider and more important role for flexibility in the future[14]. The countries reviewed in this report are all taking a proactive role in this transition and are encouraging existing DNOs / DSOs to be more proactive in the marketplace.

It is worth noting several interconnector projects are underway to link European markets to improve cross-border cooperation between;

- Germany, Belgium, France, Norway and GB;
- market coupling between Scandinavia and Central West Europe; and
- multi-regional coupling: North West Europe - South West Europe (2014, ENTSO-E).[15]

[14] IEA World Energy Outlook 2018 | Global Energy Trends

[15] www.Tennet.com Annual Accounts 2017 and associated documents

Europe has many collaborative multi-country projects looking at Smart Grid and flexibility services already underway. These projects are mainly funded by the European Commission via their FP7 and Horizon 2020 programmes. Some of these projects have already been identified and discussed by the ENA Open Networks[16] project team and are highlighted for consideration in future projects such as TRANSITION including:

- SmartNet (European Commission, Horizon 2020 framework)
- "The role of the DSO in tomorrow Electricity Market" EDSO, May 2015; EDSO = European Distribution System Operators Association for Smart
- "General Guidelines for Improving TSO-DSO Cooperation", entso-e, Nov 2015 and TSO-DSO data Management Report, entso-e, Jul 2016; entso-e = European Transmission System Operators for Electricity
- "Eurelectric Vision about the Role of DSOs", Eurelectric, Feb 2016 and DSO Viewpoints of Flexibility" Eurelectric, Mar 2017; Eurelectric is the Union of the Electricity Industry, an Association with pan-European interests
- "The Future Role of DSO and TSO Relationship" CEER, Jul 2015 and "CEER Position Paper on the future DSO and TSO Relationship, CEER Sep 2016; CEER = Council of European Regulators

Additional EU Funded Projects:

Project 1 - EU-SysFlex - Pan-European system with an efficient coordinated use of flexibilities for the integration of a large share of RES

The overall objective is to ensure an efficient and sufficient level of system services are provided to facilitate meeting world leading levels of RES-E while maintaining the level of resilience that consumers and society have come to expect from the European electricity system. This requires defining the right amount of flexibility and system services to support transmission system operators using a threefold approach. Based across Europe, the project flexibility reports are due in May 2019 with completion 2021.

https:// http://eu-sysflex.com/

[16] www.energynetworks.org/electricity/futures/open-networks-project/

Project 2 - FLEXCoop - Introduces an end-to-end Automated Demand Response Optimization Framework.

It enables the realization of novel business models, allowing energy cooperatives to introduce themselves in energy markets under the role of an aggregator. It equips cooperatives with innovative and highly effective tools for the establishment of robust business practices to exploit their microgrids and dynamic VPPs as balancing and ancillary assets toward grid stability and alleviation of network constraints.

Optimisation in FLEXCoop applies to multiple levels. It spans local generation output, demand and storage flexibility, as well as the flexibility offered by EVs to facilitate maximum RES integration into the grid, avoidance of curtailment and satisfaction of balancing and ancillary grid needs. Based in German, the project is due to complete in 2019.

https://cordis.europa.eu/project/rcn/211954/factsheet/en

5.2 The European countries in more detail:

5.2.1 Italy:

The main generation sources in Italy are fossil and hydro with a lower contribution from wind and solar. Italy is not self-sufficient and is a net importer of electricity.[17] Italy's grids are widely integrated with Switzerland, France, Slovenia, Austria, Greece and Malta.

Main observations:

- Italy is a major leader in solar generation and development and as of 2018, solar accounts for 7.9% of generation and growing;
- Wind accounts ~6% of generation and growing;
- Government is pushing the rollout of EVs with over 9,000 EV charging points installed;

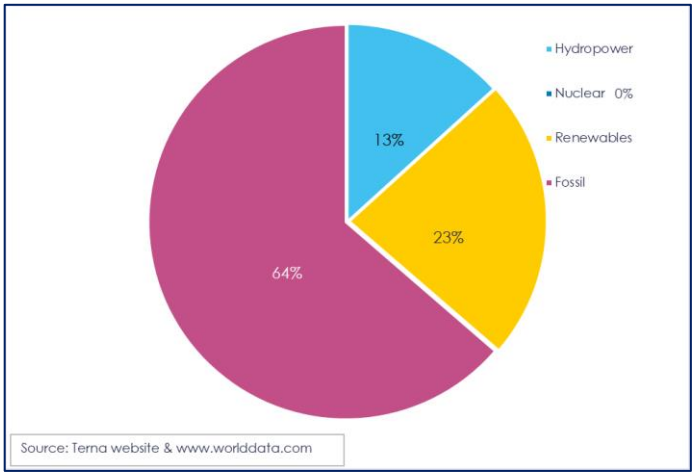

Figure 6 - Italy Energy Mix

[17] IEA Energy Policies of IEA Countries 2016 Review Italy

- Energy efficiency and demand response are heavily promoted; and
- Italy is actively involved in European Commission's FP7 and Horizon 2020 projects.

Main System Players:

Italy's electricity network is managed by one transmission system operator (TSO) (Terna) and four regional DSOs (Edison S.p.A, ENEL, ADA, Sorgenie). It has an internal balancing marketplace and takes an active part in the European Trading Market. Due to limited fuel resources, Italy still requires imported power to meet its electricity demand.[18] Most of Italy's electricity companies are active players in the European Smart Grid programme.

In summary:

The penetration of renewables and distributed generation is slowly increasing in Italy. The TSO is active in the balancing mechanism and Italy recognises that the DSOs need to progress from being passive to active players in the operation of their grids. Although still early days, Italy does recognise the need for Smart Grid and flexibility services.

Relevant flexibility services Projects:

The Italian networks operators are Involved in EU commission's projects such as Project 1. EU-SysFlex and Project 9. Go Reliable and Sustainable Grids.

5.2.2 France:

France holds a central position on the European grid and exports surplus electricity to many neighbouring countries through interconnections, including: GB, Belgium, Germany, Italy, Spain and Switzerland. France could be self-sufficient in electricity but, due to its high share of nuclear generation, continues to be a net exporter of electricity to neighbouring countries.[19]

[18] Terna's 2017 PROVISIONAL DATA ON OPERATION OF THE ITALIAN ELECTRICITY SYSTEM

[19] RTE 2017 Annual Electricity Report

Main Observations:

- Internationally, France has the second highest installed capacity of nuclear (63,130MW) after US and the highest share of nuclear in its electricity mix (78%);
- France has seen a reduction in carbon-based generation (oil and coal) which has been replaced with renewables;
- Solar and biomass account for more than 36% of the growth in renewable energy since 2005; and
- Government is pushing energy efficiency and the rollout of EVs (7 million EV charging points planned for 2030).

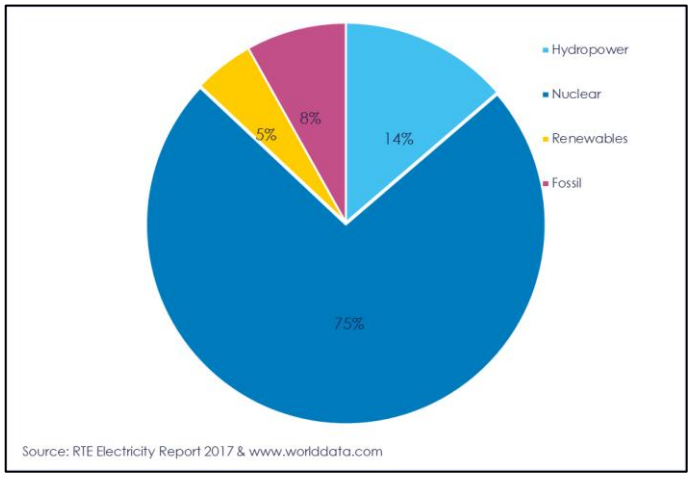

Figure 7- France Energy Mix

Main System Players: [20]

The French electricity market is dominated by the largely French state-owned company, Électricité de France S.A. (EDF). EDF is a large utility company which operates a significant portfolio of generation capacity in Europe, South America, North America, Asia, the Middle East and Africa.

EDF is the dominant electricity generator in France with their dominance in nuclear.

Réseau de transport d'électricité (RTE, a subsidiary of EDF), is the TSO in France which manages the high-voltage transmission network, is responsible for balancing the grid and for operational security of the electricity system.

Enedis (another subsidiary of EDF) is the key DSO in the French market with other local DSOs including: Electricité de Strasbourg (ESEnergies), Sorégies, Gaz Electricitéde Grenoble (GEG), EngieSA, CieNationale du Rhône SA.

At a retail and trading level, EDF are also the dominant company in the supply market although there are about 100 companies with a buy and resell authorisation in the France market.

[20] IEA Energy Policies of IEA Countries France 2016 Review

In Summary:

France is moving from fossil generation to renewables which has increased the understanding of and need for flexibility services at distribution voltage levels. France recognises the DSO needs to become more proactive using flexibility services at lower voltage levels.

Most of France's network companies are active players in the European Commission's Smart Grid Project initiatives and EDF's GB-based subsidiary UKPN is actively involved in Ofgem's LCNI and NIC initiatives.

Relevant flexibility services projects:

Project 3 - REFLEX – Analysis of the European energy system under the aspects of flexibility and technological progress

The future energy system is challenged by the intermittent nature of renewables and requires therefore several flexibility options. Still, the interaction between different options, the optimal portfolio and the impact on environment and society are unknown. It is thus the core objective of REFLEX to analyse and evaluate the development towards a low-carbon energy system with focus on flexibility options in the EU to support the implementation of the SET-Plan. Horizon 2020 Work Programme "Secure, clean and efficient energy" of the EU.

Project 4 - Magnitude – Bringing Flexibility provided by multi energy carrier integration to a new MAGNITUDE (Project ID: 774309)

Magnitude addresses the challenge to increase the amount of electricity flexibility, by increasing the synergies between electricity, heating/cooling and gas networks. Magnitude technical solutions, market design, and business models, to be integrated on ongoing policy discussions.

Project 5 - ENERGY.2010.7.1-1 - Large-scale demonstration of smart electricity distribution networks with distributed generation and active customer participation.

The Nice Grid project is one of six smart grid demonstrations within the large-scale Grid4EU project, which aims to test advanced smart grid solutions with wide replicability and scalability potential for the European market. The French Riviera receives a life-size demonstration project for the flexibility and efficiency of lithium-ion battery systems integrated at different electricity grid levels.

5.2.3 Germany:

Germany has a well-balanced generation mix, good interconnections to other European countries and is capable of generating all its electricity requirements. There is significant cross-ownership of distribution and retail in Germany's electricity sector through the country's many regional and local utilities, or Stadtwerke.

Germany has a high share of renewables with large amounts of solar in the south and wind in the north.

Main Observations:

- Slowly reducing the reliance on coal;
- High share of renewables with large amounts of solar in the south and wind in the north;
- Over 800 registered distribution system operators (Nov-17);
- Very active in encouraging smart and flexibility as solution to the network imbalance and in working with FP7 and Horizon 2020 funding schemes;
- Government is pushing energy efficiency to reduce overall electricity demand; and
- EVs are now seen as a major challenge for the local network operators.

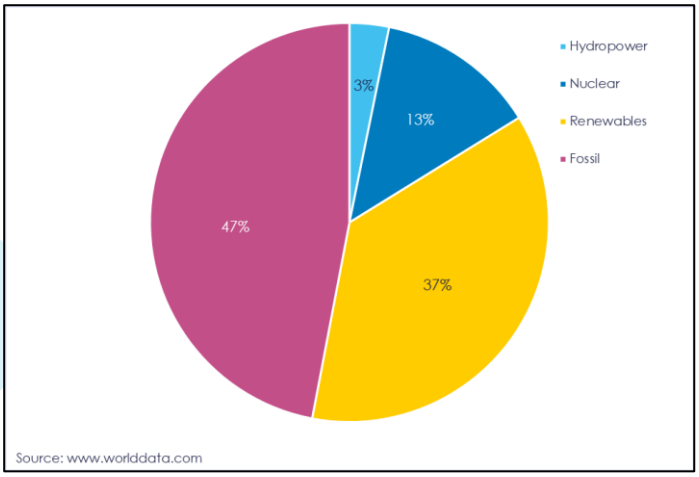

Figure 8 - Germany Energy Mix

Main System Players:[21]

Four large electricity companies dominate generation (EON, RWE, EnBW and Vattenfall).

There are 4 TSO in Germany, these are Amprion, TenneT, TransnetBW and 50Hertz.

The distribution system is very fragmented and is run by over 800 registered DSOs. The management of the distribution grid is seen as a huge challenge and flexibility services are seen as a great help to the grid operators.

[21] IEA Energy Policies of IEA Countries Germany

In summary:

Germany has a very central role in the European Transmission Grid. It has good interconnections with neighbouring countries and takes an active part in the European Trading and Balancing marketplace. All the big four and many of the German DSO's are involved with the European Commission's Smart Grid initiatives. However, flexibility services are still in their infancy.

Relevant flexibility services projects:

Project 6 - InterFlex: (USEF) Flexibility in Action

In InterFlex explores pathways to adapt and modernise the electric distribution system consistent with the objectives of the 2020 and 2030 climate-energy packages of the European Commission. Six demonstration projects are conducted in five EU Member States (Czech Republic, France, Germany, The Netherlands and Sweden) to provide deep insights into the market modernizing their systems. European Union's Horizon 2020 research and innovation programme under grant agreement n°731289. The project began in January 2017 and will run for 3 years.

www.interflexstrijp.nl/the-project

Project 7 - Enera (USEF) is a 33 organisation consortium project funded by the Federal German Ministry of Economics and Energy. Using USEF It aims to develop and demonstrate scalable solutions for energy transition in three areas: grid, market and data. Central element of the project is a flexibility platform developed by EPEX SPOT, on which system operators TenneT, Avacon Netz and EWE NETZ enter into flexibility contracts with aggregators. USEF is supporting consortium party EWE in development and specification of a mechanism that allows system operators to verify the actual delivery of flexibility for the purpose of congestion management. The mechanism will be demonstrated in a framework that allows flexibility to be used for multiple purposes. Implemented in 2018, there will be a two-year proof of concept demonstration during 2019/2020.

http://www.enera.eu/en/

Project 8 - TenneT Cooperation Project Grid Stabilisation - Vehicle 2 Grid

In spring 2018, TenneT, the energy service provider The Mobility House and the automobile manufacturer Nissan launched a joint pilot project to investigate whether electric cars can contribute to solving the grid stabilisation problem. In addition, proposals for regulatory guidelines for the "Vehicle-to-Grid" concept will be developed and evaluated. First results are due in 2019.

https://www.tennet.eu/our-key-tasks/innovations/nissan/

5.2.4 Spain:

The generated output of Spain is enough to meet its own electricity requirement with enough excess generation to trade with foreign countries. Spain has a large, well-diversified, generation fleet and a very reliable power system[22]. It has also succeeded in integrating a large share of wind and solar while limiting renewable curtailment. As the country has relatively low cross-border capacity, variations in power generation must be dealt with largely within the Spanish system.[23]

Main Observations:

- Spain is now the world's third largest liquified natural gas (LNG) user, after Japan and South Korea;
- Wind and solar generation have boomed over the past decade while carbon-based generation has nearly halved;
- Government is pushing energy efficiency and EVs with 5,000 EV charging points installed; and
- Spain has interconnectors with Portugal, Morocco and France and is in the process of doubling the capacity of the interconnections with France.

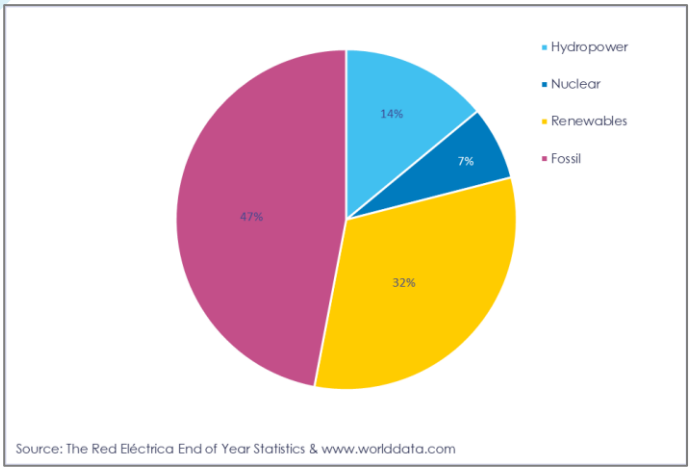

Figure 9 - Spain Energy Mix

[22] IEA - Energy Policies of IEA Countries - Spain

[23] REE Red-Electrica-Infografia-Sector-Electrico-End of Year forecast

Main System Players:

The Spanish high-voltage transmission network is owned and operated by the TSO, REE. Spain has five major distribution companies: Endesa, Iberdrola, Gas Natural Fenosa, EON and HC Energia-EDP, and subsidiaries of each company of these companies are involved in electricity generation and supply. In addition, there are over 300 smaller companies involved with electricity supply.

In summary:

The TSO is concentrating on increasing the number and capacity of interconnectors with its neighbouring countries. Spain recognises the need for more flexibility services and as a result the Spanish DSOs are actively involved in many of the EU collaborative projects and, through SP Energy Networks, Ofgem's LCNI and NIC initiatives. Other than traditional balancing services and a commitment to use flexibility services for the future, it is still early days for flexibility services.

Relevant flexibility services Projects:

Project 9 - "GO15. Reliable and Sustainable Power Grids"

GO15 is a voluntary initiative of the world's 16 largest Power Grid Operators, with the aim of leading the transition to the future power grid. The objective of DSM (Demand Side Management) is to maximize the efficiency of the electric grid by enabling end-users to base usage decisions not only on their value of electricity but also on actual grid conditions. The main goal of the GO15 Joint activities is to develop findings and recommendations on strategic issues facing global grid operators selected by the Steering Board ("What keeps CEOs awake at night?").

http://www.go15.org/

5.2.5 The Netherlands:

Electricity in the Netherlands is produced mainly from natural gas and coal with several producers generating electricity from sustainable sources such as wind, solar, and biomass. The Netherlands is well connected to its neighbours and the TSO, TenneT, operates a transmission network in Germany and is helping to establish a single market across Europe.

Main Observations:

- Currently building additional transmission interconnectors with immediate neighbours, Germany and Belgium;
- A big push for renewables with 16,000MW of solar connected to the network and 500MW of wind and increasing;
- Current push to improve energy efficiency in buildings;
- Big push by government to remove fossil fuelled cars – 3,500 electric vehicles sold at end of 2017;
- Large number of flexibility and V2G projects underway and reports suggest The Netherlands is the hub of EV development.

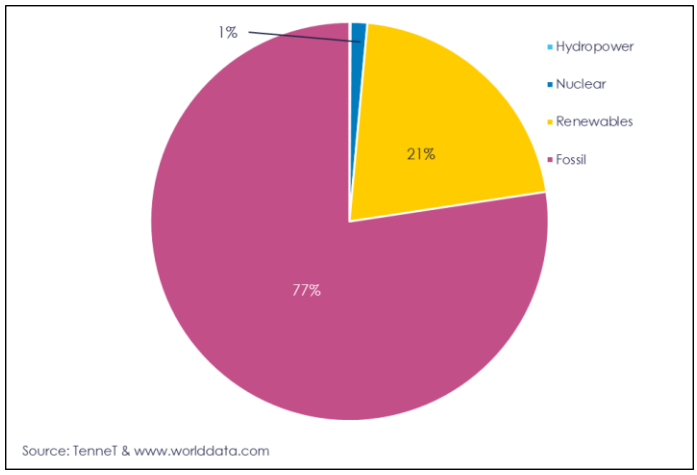

Figure 10 – The Netherlands Fuel Mix

Main System Players:

The Dutch power sector is unbundled, with a TSO (TenneT), eight DSOs, over 25 generating companies, and 35 electricity retailers.

In summary:

Although the Netherlands is already well connected electrically to its neighbours it is working hard to increase the capacity of these interconnectors. There is a big government push to remove fossil fuelled cars and increase renewable generation.

The northern part of the country is rich in natural gas which powers most generation with the Dutch and this defines the traded markets. Only 6% of energy comes from renewable sources, partly due to the absence of large-scale hydro, solar usage, and onshore wind (due to population density).[24]

[24] www.export.gov/article?id=Netherlands-Energy

Relevant Flexibility Projects:

There are numerous smart grid/ flexibility projects underway in the The Netherlands using the market and settlement Universal Smart Energy Framework (USEF) – see projects below.

Project 10 - Hoog Dalem home-battery system increases the flex-value of solar (USEF)

Trialled domestic battery systems combined with solar production and a smart in-home system in 42 homes. USEF was used to decrease the impact of the solar generation on the local grid by maximising self-consumption. Tests included the optimised use of self-produced solar electricity, peak reduction by use of storage as well as customer response on this new energy system. The outcome indicated that provided enough flex is offered, the system works as hoped.

https://www.usef.energy/app/uploads/2016/12/HD_report-2.pdf

Project 11- Dynamo Flex Market Development (USEF)

DYNAMO aims to prove that flexibility can address increases in demand and generation and the resulting congestion while avoiding or postponing infrastructure investment. It is establishing a USEF-based functional flexibility market to solve issues across three active locations. The initial challenge is in Nijmegen, where there are large residential and business developments and renewables infeed is projected to double. The aggregator is guaranteed a minimum number of activations and there is an agreed maximum congestion price.

www.usef.energy/interview-with-lineke-goorix/

Project 12 - Energiekoplopers (USEF Smart energy use decreases power outages)

The EnergieKoplopers project in Heerhugowaard tested a USEF flexibility market for the first time. Smart appliances were installed at 203 households, which enabled flexible electricity consumption. The smart appliances were automatically controlled by a smart IT system. The project demonstrated that the USEF flexibility market worked to address issues in the energy system and created value for participants in the flexibility market.

www.usef.energy/app/uploads/2016/12/EnergieKoplopersEngels_FinalReport_2016_vs4-1.pdf

Project 13 - Smart Solar Charging

Smart Solar Charging is a consortium project in Utrecht, Netherlands. During periods of high solar production and low demand, surplus energy is stored in the batteries of a pool of EVs. The DSO, Stedin, is looking to use this flexibility using USEF via a multi-aggregator market during periods of congestion or high market prices. Initially the only aggregator will be Jedlix who will enable EV users to set their smart charging preferences via an app so demand and flexibility can be forecast one day ahead at 15 minute intervals. The DSO matches total demand with estimated generation, demand and capacity to identify when and where there will be congestion and makes a flexibility call to Jedlix. The project began in January 2017 runs for 3 years.

www.smartsolarcharging.eu/en

5.2.6 Norway:

Norway is a major oil and gas provider and a leading country on reducing carbon emissions with some of the most ambitious /targets. It is, uniquely using its large oil and gas revenue, to invest in developing new solutions for a low-carbon future.

Norway's grid is dominated by hydro which accounts for 96% of electricity generation. The system is highly integrated into the Nordic power system that has interconnectors to the Baltics, Northern Europe and the Russian Federation.[25]

Main Observations:

- Norway is a highly integrated electricity system with interconnectors to Sweden and the Baltic countries;
- The combination of high levels of interconnection and its large hydro fleet means Norway can provide the region with a significant source of low-cost, highly flexible, and zero-carbon generation;

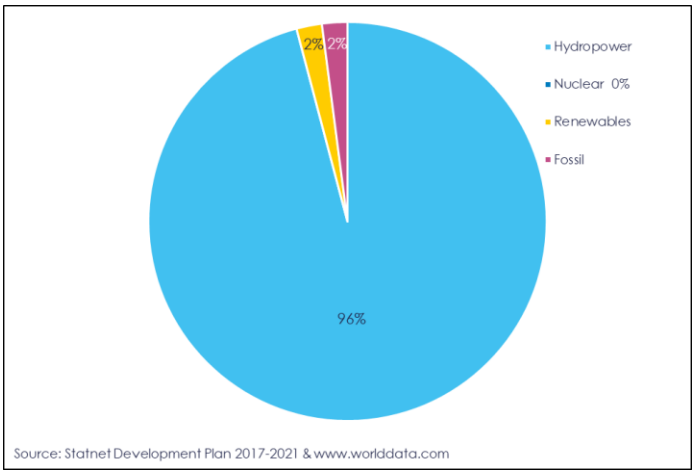

Figure 11 - Norway Energy Mix

[25] Smart grid outlook Norway 2017

- Government pushing energy efficiency in buildings;
- New interconnector currently being installed across the North Sea to Great Britain;
- Norway has one of the highest uptakes of EVs with representing 31.2% of all new cars sales in 2018[26].

Main System Players:

Twenty different entities own and operate the transmission network, but Statnett is the only TSO in Norway. In addition, Norway's network is managed by 146 monopoly DSOs. [27]

In summary:

Norway's electricity system is well interconnected with those of neighbouring countries. It plays in the Nordic Electricity Markets and nearly all its imports and exports are transmitted via land interconnectors to Sweden or subsea cables to Denmark and the Netherlands. Hydropower accounts for the bulk of the total installed capacity and pumped storage is used as a main balancing tool.

Most of the electricity companies and some of the DSO's are involved with the European Commission's Smart Grid initiative. Although it is still early days for flexibility services.

Relevant Flexibility Projects:

Although Norway is a major supporter of a low carbon future there are no relevant flexibility services projects to report on currently.

5.2.7 Sweden:

This Scandinavian nation already has an almost carbon-free electricity supply. It could be self-sufficient in electricity but trades energy with neighbouring and interconnected countries. It is increasingly integrated within the Nordic and Baltic electricity markets, and electricity certificate market with Norway offers a unique model for other countries and sees smart grids as an asset.[28]

Sweden's electricity supply is dominated by hydro and nuclear power with the remainder a mix of renewable generation (primarily wind and biomass) and fossil generation (coal, oil, and natural gas).

[26] https://www.reuters.com/article/us-norway-autos/norways-electric-cars-zip-to-new-record-almost-a-third-of-all-sales-idUSKCN1OW0YP

[27] Statnett System operations and market development plan 2017–2021

[28] Energy in Sweden 2018 An overview

Main Observations:

- Highly integrated electricity system with interconnectors to Norway and the Baltic countries;
- Sweden is looking to further increase investment in clean energy technologies;
- It is part of the Nordic electricity market; and
- Sweden has a well-developed district heating sector.

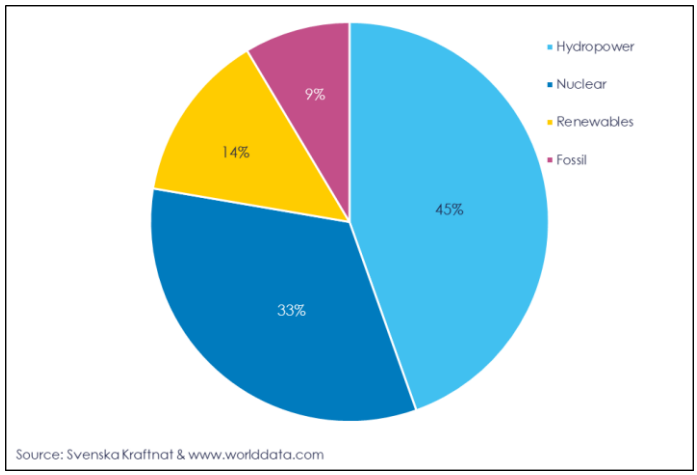

Figure 12 - Sweden Energy Mix

Main System Players:

The Swedish grid is divided across 170 grid companies as follows:

- transmission grid - owned and operated by the TSO, Svenska Kraftnät (wholly owned by the Swedish government) and unbundled from other activities in the electricity sector;
- regional grids - three companies own the majority of the 13 regional grids (E.ON Elnät Sverige, Vattenfall Eldistribution and Fortum Distribution) who distribute electricity to local grids and large customers; and
- local grids - distribute electricity to private households, factories, etc and are owned by the state, municipalities, private companies, and economic associations.

The retail market is supplied by three large suppliers (Vattenfall, EON Sweden and Fortum) and several smaller network companies with less than 1,000 customers each.

In summary:

Still early days for flexibility services.

Relevant flexibility services Projects:

Although no projects are highlighted, most of the Swedish operators are involved with Smart Grid projects across Europe.

5.2.8 Great Britain:

Great Britain has a well-balanced generation mix with interconnectors to France, the Netherlands and Ireland. It is a net importer of electricity to maintain supplies to customers. GB has seen a huge swing away from fossil generation to renewables including wind (onshore and offshore) and solar.

GB is very supportive of smart grids. Government innovation funding has exceeded £1 billion since 2010 and delivered savings in excess of £1.7 billion[29]. There has been an acceleration in third party connections for generation and energy storage. As a result, there has been an escalation of constraints on lower voltage grids. In addition, there is an increase in low carbon transport as Government seeks to decarbonise transport. The Project TRANSITION work will identify and trial potential flexibility solutions for these future challenges. [30]

Main Observations:

- Has recently seen several older coal generation stations shutdown due to the Industrial Emissions Directive and the mothballing of gas generation due to market conditions;
- Solar and offshore wind generation have grown significantly with 13,100MW of solar, 13,500MW onshore wind and 1,800MW of offshore wind[31] connected to the grid (and increasing);

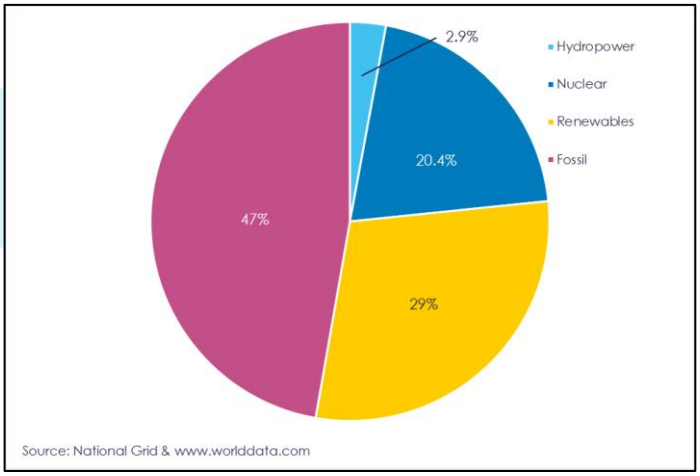

Figure 13 - GB Energy Mix

- There is a big push by Government to remove fossil fuelled cars from roads with 210,000 EVs[32]; and

[29] http://www.energynetworks.org/assets/files/electricity/futures/network_innovation/electricity_network_innovation_strategy/Energy%20Networks%20Association%20-%20Electricity%20Network%20Innovation%20Strategy-March%202018.pdf

[30] www.National Grid.com/various pages

[31] https://asset.publishing.service.gov.uk/governemtn/uploads/system/uploads/attachment.data/fil/789370/renewables March 2019.pdf

[32] https://www.smmt.co.uk/vehicle-data/evs-and-afvs-registrations/

- Constrained Managed Zones and Active Network Management schemes are already being installed as BaU across GB by the DNOs.

Main System Players:

The GB electricity sector is unbundled, with National Grid fulfilling the dual roles of transmission system and Electricity Systems Operator (ESO) for GB and the Transmission Network owner for England and Wales. Scottish Hydro Electric (SHE) Transmission is the Transmission Network owner in the north of Scotland and SP Transmission is the Transmission Network owner in the south of Scotland.

There are 14 distribution zones managed by six DNOs[33], over 25 independent generators and over 60 electricity retailers. In 2005, the British Electricity Trading and Transmission Arrangements were introduced that created fully competitive British-wide market for the trading of electricity generation.

In summary:

The GB electricity system is well balanced, but the pressure on the network from increasing penetration of renewables has resulted in significant system constraints at all voltage levels. This results in existing new projects being constrained from generating at their installed capacity whilst developing projects face high costs and / or risk of planned or unplanned constraints to their planned running regime. Further, any such constraints are often focussed on newer, lower carbon projects, at the expense of older, higher carbon projects.

GB is already well connected electrically to neighbouring countries with interconnectors and their number are planned to increase. There is a big Government push to remove fossil-fuelled cars and increase renewable generation.

Relevant Flexibility Projects:

A number of DNO-DSO projects are being supported by Ofgem's National Innovation Competition (NIC) initiative, with the GB's TSO and DNOs involved in several smart grid and flexibility projects. The TSO and DNOs are also involved with a number of the EU Commission projects with neighbouring countries.

Three projects awarded under the 2017 NIC to investigate and trial flexibility (TRANSITION, FUSION and EFFS), have been directed by Ofgem to work collaboratively to maximise the collective benefits of each project, allow for a deeper understanding and to quantify and validate the functional outputs. Together with ON-P, they will play an important role in the development of the future of the DSO.

[33] CGI Energy Flexibility for Dummies – page 25

Project 14 - Project FUSION (USEF)

This project will trial commoditised local demand-side flexibility through a structured and competitive market-based framework using USEF, enabling the DNO and all market actors to unlock the value of local network flexibility. The project will aim to demonstrate how DNOs can harness this flexibility to efficiently manage modernised networks.

Project 15 - Project EFFS

The project will deliver a practical robust and accurate system capability that will enable a DNO to actively manage the provision of flexibility services necessary for transition to becoming a DSO. Having specified requirements, the project will consider the technical options for delivering the required functionality. The selected technical option will then be built to support a short trial, to demonstrate that the software can support the functionality specified.

Project 16 - ENAs Open Network project

This is one of the largest energy industry initiatives that will transform the way our energy networks work, underpinning the delivery of the smart grid. This project brings together 9 of UK and Ireland's electricity grid operators, respected academics, NGOs, Government departments and the energy regulator Ofgem.

The project will:

- Help give households, businesses & networks the ability to take advantage of new energy technologies to take control of their energy and lower their costs
- Help underpin business growth, attract investment and deliver real economic benefits to the UK
- Take a whole energy system approach to designing solutions by consulting with a wide range of stakeholders, including the gas networks, through the Advisory Group

www.energynetworks.org/electricity/futures/open-networks-project/open-networks-project-overview/

5.3 Asia:

5.3.1 Japan:

Japan is an island with no interconnection with any other countries and a high dependence on imports for primary energy supply.

The Fukushima disaster in 2011 because of the tsunami resulted in the shutdown of all nuclear generation in Japan with only 9 of 46 reactors online at the end of 2018. The generation shortage has been filled with very expensive and carbon intensive fossil fuels, primarily LNG but also oil and coal.[34]

Japan has recently moved from a system of regional monopoly supply companies towards a more liberalised market system. The country is currently undergoing a market liberalisation with competition in retail released in 2016.[35][36]

Main Observations:

- Japan is very aware of emergencies and energy storage is common in buildings to help with power blackouts;
- Japan has developed highly-advanced technologies to utilise coal, so that coal will remain a critical fuel for generation of their future;
- Renewables accounts for 9% of Japan's generation mix but is expected to increase to between 20% and 23% by 2030 with solar forecasted to play a major part;

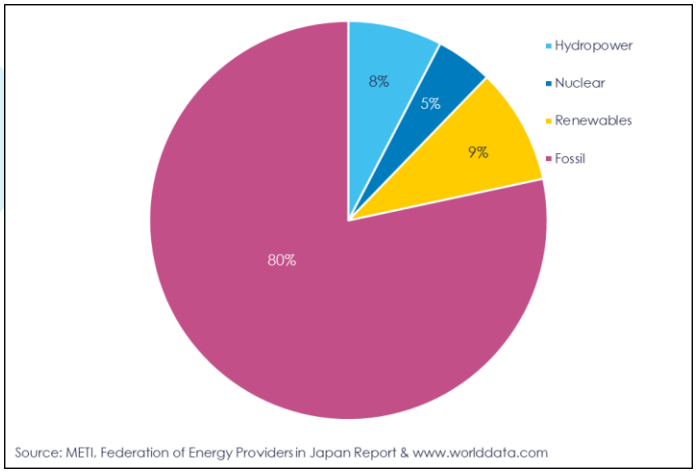

Figure 14 - Japan Energy Mix

- Japan has an increasing interest in low carbon transport, hydrogen and smart technologies and solutions;
- Government is pushing energy efficiency on buildings;

[34] Energy Policies of IEA Countries 2016 Review

[35] METI & JAPAN'S ENERGY 20 Questions to understand

[36] ELECTRICITY REVIEW JAPAN the Federation of Electric Power Companies of Japan 2017

- Nuclear still features strongly in Japan's future energy strategy with reactors now being switched back on.

Main System Players:

There are 10 vertically integrated regional energy companies managing the transmission and distribution grids, consisting of mainly overhead lines with only a small underground network. There are now over 500 companies operating in the new competitive retail and trading markets since liberalisation of the retail market.[37]

In summary:

Japan's electricity network is divided historically by the frequency used: eastern Japan operates at 50 Hertz (Hz) and western Japan at 60 Hz. Japan has strong targets to introduce more renewables into its generation mix and as a result sees the challenges to maintain a balanced grid.[38]

Relevant flexibility services Projects:

Project 17 - GridShare rollout for ITOCHU Smart Star batteries

Moixa has been working closely with ITOCHU to integrate their customer on-boarding process to the GridShare platform, enabling efficiencies in managing the life cycle of customers, designing and automating processes and increasing visibility of customer status. In addition, they have created customised and localised GridShare portals, dashboards and client apps for ITOCHU. These allow the customer value to be determined and provide alerts of particular conditions on customer systems; while their customers understand and engage in their energy flow and savings with live data and regular feedback. Moixa partners with Itochu in Japan to use artificial intelligence to help home batteries learn smart behaviour.

http://www.moixa.com/press-release/moixa-partners-itochu-japan/

[37] https://thelawyersreviews.co.uk/edition/the-energy-regulation-and-markets.review.edition-7/1171254/japan

[38] Abeam Consulting Overview and Electricity Market May 2019

Project 18 - Nissan and TEPCO VPP

Nissan and TEPCO launch virtual power plant project based on Nissan EVs to study the potential for managing grid demand. A group of TEPCO employees using the Nissan e-NV200 electrical commercial van and Nissan employees using the 100% electric Nissan LEAF, the world's best-selling electric vehicle, will participate. The project starts today and will run until the end of January.

Reference: Nissan and TEPCO launch virtual power plant project

Project 19 - Conjoule

Tokyo Electric Power Company Holdings Inc. started a project to set up a peer-to-peer electricity trading platform together with German power firm Innogy SE. The platform allows participating individuals to directly sell their surplus solar power to local supermarkets and companies via transactions using smartphones. The service is slated to begin in Germany as early as this month. The project aims to attract 10,000 individual and corporate subscribers by 2020. The platform uses blockchain, the core technology that enables high security crytocurrency transations at low costs. The two power firms will charge a commission for transactions on their platform. Tepco hopes to start a similar service in Japan within the next decade.

https://www7.tepco.co.jp/newsroom/press/archives/2017/1443967_10469.html

Project 20 - Kansai Electric Power Co., Inc. is progressing a Virtual Power Plant Construction and Demonstration

Storage batteries for home use and industrial use are becoming more widespread. With the expansion of renewable energy and the introduction of the feed-in tariff system, storage batteries are effective for optimizing the electric power demand-supply balance. The VPP aims to construct a structure that will function if it is a single power plant (virtual power generator) with the integrated control of supply and consumption of electricity utilizing IoT technology as well as storage batteries. This will enable the power grid to better coordinate the demand and supply, and pave the way for the introduction of more power sources based on renewable energy. It will also generate new extra value, such as application for Megawatt power transactions with Demand response

5.3.2 China:

China is the largest energy user in the world. The abundance of local coal means it is still the fuel of choice with over 1,010,000MW of coal capacity installed[39] (by comparison, USA has less than 250,000MW). Other fuels, particularly hydro and renewables have increased and will help reduce the reliance on coal over time. In recent years, China has recognised the significant effect of coal emissions on local air quality and carbon dioxide emissions,[40] but there are signs that new coal capacity continues to grow and is likely to exceed the 2020 target of 1,100,000MW[41], although this could be argued at the expense of retiring older plant[42].

China is also focussing on clean energy with the long-term objective of substantially reducing its reliance on coal and reducing its greenhouse gas emissions. "China is in the beginning of an energy transition with the aim to build an energy system for the future …," Wang Zhongying, Acting Director General, Energy Research Institute of China Academy of Macroeconomic Research.[43]

Total renewable capacity, including hydro and biomass as well as solar and wind, rose to 728,000MW by the end-2018 (38.3% of installed capacity)[44].

Main Observations:

- The UHV transmission grid continues to be extended with a 1,100kV line connecting 12 large power plants over nearly 2,000 miles to coastal load centres due to be commissioned in 2019;
- Generation mix starting to move from coal and oil to renewables with a target of 50% by 2030;[45]
- China has the largest renewables projects in the world; Tengger Desert (solar, 1,500MW), Gansu (wind, 8,000MW increasing to 20,000MW in 2020) and Three Gorges (hydro, 22,500MW);
- Energy Efficiency and Energy Storage will also feature significantly in the future with a 100MW, 720MWh storage project due to be commissioned in 2019;

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[39] https://af.reuters.com/article/energyOilNews/idAFL3N1ZU20A

[40] Web pages: China Southern Power Grid and State Grid

[41] https://endcoal.org/wp-content/uploads/2018/09/TsunamiWarningEnglish.pdf

[42] https://phys.org/news/2019-02-coal-consumption-worldwide.html

[43] China Renewable Energy Outlook 2018 - Energy Research Institute of Academy of Macroeconomic Research/NDRC China National Renewable Energy Centre

[44] https://uk.reuters.com/article/us-china-renewables/chinas-2018-renewable-power-capacity-up-12-percent-on-year-idUKKCN1PM0HM

[45] A Star for China's Energy Transition Five Golden Rules for an Efficient Transformation of China's Energy System – CNREC & Agora

- China has a significant drive towards low carbon transport with over 730,000 charging points and had 1.3 million EVs by end 2018 with annual growth expectation of 40% of new vehicles; and
- Flexibility services will be at the centre of the "new" and more low carbon energy market in the future[46];

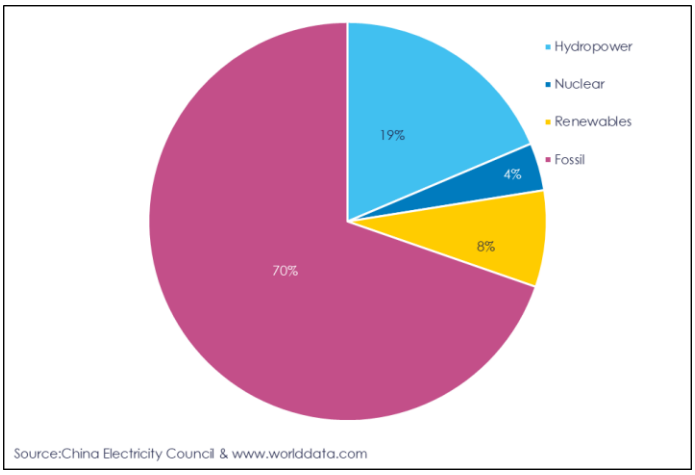


Figure 15 - China Energy Mix

Main System Players:

China electricity system is managed and operated by two Operators, China Southern Power Grid Co and State Grid, Cooperation of China.

In summary:

Although China is some way behind Europe and North America on the smart grid front, they will, with their 2018-2020 plan[47] and their proposed significant investment, undoubtedly catch up quickly. Therefore, it is no surprise that it is still very early days for flexibility services.

Relevant flexibility services Projects:

No flexibility services Projects were found in this investigation.

Figure

5.3.3 South Korea:

South Korea has a lack of natural resources and, like Japan, is a net importer of energy fuels (coal, LNG and gas). Government recently announced: "South Korea plans energy U-turn away from coal, nuclear to renewables," *(source Reuters June 2017)*. This means a big shift away from its reliance on fossil generation to secure the country's electricity supply.

Generation from renewable sources is increasing, however currently only accounts for 7% of the total generation, (although it is forecast to rise to 30% by 2030). Already, South Korea currently has some of

[46] RE100 china analysis | April2015

[47] https://uk.reutures.com/article/us-china-renewables/chins-to-launch-power-quota-system-by-yeat-end-idUKKBN103OUM

the largest solar farms in the world. Flexibility and system balancing mainly uses existing thermal and hydro generation.

Main Observations:

- New Government push on moving away from reliance on fossil fuel generation to renewables[48];
- Extending transmission network;
- KEPCO and Kookam are building the world's largest grid scale energy storage system for frequency regulation (500MW) in South Korea;
- Korea is actively involved in smart grids and blockchain flexibility platforms;

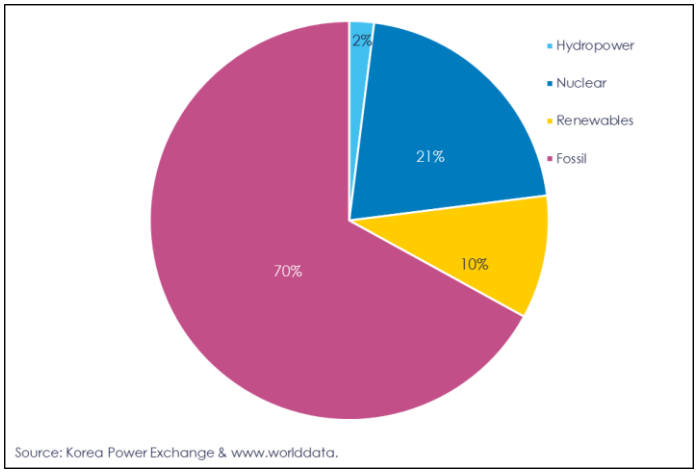


Figure 16 - South Korea Energy Mix

- KEPCO participated in the construction of the Jeju Island Smart Grid Verification Centre, taking charge of the business model;
- The GB Government department (BEIS) has recently signed a bilateral agreement with South Korea to provide collaboration on three Smart Energy projects; EV Charging, Flexibility Blockchain Trading Platform and Liquid Air Storage system.

Main System Players:

KEPCO is the main integrated electricity utility company, having an effective monopoly over the transmission, distribution and retail side of electricity in South Korea. The generation industry currently consists of KEPCO's six wholly owned generation subsidiaries and 17 independent generators. In 2017, just one of KEPCO's subsidiaries generated the majority of electricity in South Korea and was responsible for ~71% of total generation capacity. The electricity market is managed and controlled by Korea Power Exchange (KPX).[49]

[48] https://www.reuters.com/article/us-southkorea-politics-energy/south-korea-plans-energy-u-turn-away-from-coal-nuclear-idUSKBN18V0EH

[49] KEPCO Website - Overview of Korean Electricity Grid

In summary:

Generation of electricity is concentrated in the southern provinces with consumption concentrated in the metropolitan areas. Therefore, long-distance electricity transmission is essential; it is difficult to use market mechanisms to control demand. Large investments are required in new generating capacity to secure future electricity supply. South Korea is planning on a major shift away from fossil generation to renewable generation. KEPCO participated in the construction of the Jeju Island Smart Grid Verification Center and leads the project which is developing the business model, intelligent transportation, new and renewable energy, and power services. The consortium plans to continue with the next phase of the project and build customized business models in collaboration with participating municipalities in 2016-2018.[50]

The Korean Power Exchange (KPX) is now putting its efforts into demand resource trading, Renewable Energy Certificates, Energy Storage System, and smart grid development to strengthen the electricity business platform initiatives and invigorate the national economy.

Relevant flexibility services Projects:

Project 21 - Project Artemis: GridWiz / Electron

This project will pilot an energy flexibility trading platform in South Korea. The partners will collaborate to research, design and test energy flexibility products for the South Korean electricity market. Building upon Electron's existing flexibility trading platform, the project aims to assist the development of a marketplace that can provide price signals to incentivise demand side response capacity, maximise the value of existing assets and inform investment decisions for flexibility providers and grid operators.

https://www.gov.uk/guidance/funding-for-innovative-smart-energy-systems#funding-for-uksouth-korea-bilateral-collaboration-on-smart-energy-innovation

Project 22 - KEPCO: Various Smart/ Micro Grids projects:

The development of the Jeju island demonstration project continues with additional projects being funded including; Frequency Regulation, Gasa Island Micro Grid, Gapa Island Micro Grid, and Smart Demonstrator Jeju Island.

[50] KEPCO Website – Jeju Island Smart Grid & New Energy Business project

5.4 Oceania;

5.4.1 Australia

Australia is very supportive of renewables due to the high annual sunshine hours. Australia's electricity network and regulation have generally followed the GB's system which has served them well over the years. However, the main concerns in Australia is the increasing penetration of wind and solar, together with their ageing coal generation plants.

Australia is still very reliant on fossil generation, however the electricity system required to support Australia's modern economy and lifestyle is experiencing change on an unprecedented scale with aspirations of a future where up to 45% of all electricity is generated by customers and Australia achieving zero net emissions by 2050[51].

Main Observations:

- Coal generation is slowly being replaced by renewables;
- Australia has the highest average solar radiation per square meter of any continent in the world and more than 1.6 million rooftop solar systems had been installed in Australia by November 2016 equating to more than 5,200MW of installed solar capacity;
- Energy Efficiency and Demand Side Management are being promoted by Government including the roll out of energy storage schemes;
- The Australian Electricity Network Association has published a Transformation Roadmap[52].
- Large scale blackouts on their long, thin and radial grids are a major concern in Australia and this has resulted in reform of the market.

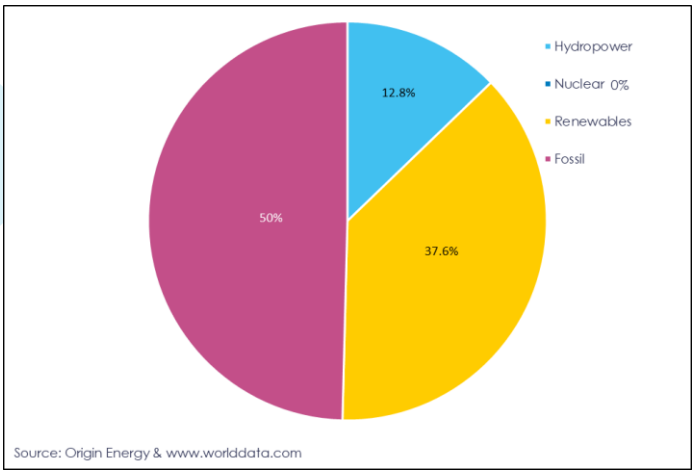


Figure 17 - Australia Energy Mix

[51] CSIRO and Energy Networks Australia 2017, Electricity Network Transformation Roadmap: Final Report

[52] www.energynetworks.com.au/electricity-network-transformation-roadmap

Main System Players:

Australia has 16 major electricity distribution grids (district network service providers). Distribution grids are state-owned but leased in South Australia and New South Wales (Ausgrid, Endeavour Energy), except for rural NSW Essential Energy which remained state-owned.

In Summary:

Australia has an extremely favourable policy environment for small-scale solar installations, and South Australia has the highest rooftop solar penetration rate per household in the world, reaching 29% of dwellings in 2016 *(AEMO, 2016)*. Flexibility and reliability have become strongly interlinked with the growth of generation from variable renewable energy.

Australia is still reliant on coal for most of its generation but has huge potential for renewable generation. Australia is already using energy storage units to support the network (not only the well-publicised TESLA large battery) and Ergon Energy is installing domestic batteries to remote rural locations to avoid huge reinforcement costs.[53]

It is still early days for flexibility services.

Relevant flexibility services projects:

The Australian Government is supporting many Demand Response projects including:

Project 23 - Chargefox Electric Vehicle:

Chargefox network of ultra-rapid charging stations will play a significant part in improving Australia's infrastructure and remove one of the major barriers that limits the adoption of electric vehicles (EVs). The charging stations will enable all modern EV drivers to confidently drive between Australia's major cities. In this project, Chargefox will secure 21 locations for the network on major driving routes across the country.

Project 24 - Australian Electricity Network Association: Transformation Roadmap publications can be downloaded from www.energynetworks.com.au/roadmap

[53] www.arena.gov.au/projects/trialling-a-new-residential-solar-pv-and-battery-mode

Project 25 - Ausgrid Power2U Project:

The Ausgrid Power2U project involves the establishment a $4.1 million fund to help selected customers to permanently reduce their electricity use on Ausgrid's network. By permanently reducing customer demand for grid supplied electricity, Ausgrid can delay, or avoid, network investment and, over time, lower the cost of electricity for all customers.

https://arena.gov.au/projects/ausgrid-power2u/

Project 26 - Tempus Energy & Origin Energy

Trial demand management in South Australia, Tempus is partnering with Origin to pilot flexible energy demand management in South Australia.

Tempus Energy's technology is a demand-side management platform that lets customers use flexible load in their own assets and building management systems.

5.4.2 New Zealand

New Zealand is endowed with a diverse range of energy sources, notably renewables and has a high penetration of geothermal energy and a significant contribution from hydro. The country is a net importer of petroleum products but could be self-sufficient. It does rely on 50% of fossil generation and has policy to reduce its reliance.

The New Zealand government's strategy is for more renewable generation together with batteries, energy efficiency and demand response to support the grids. However, a low carbon transport programme could add to the grid's issues.

Main Observations:

- Government is on a drive for renewable generation with battery and EV support;
- Flexibility services will be required to balance the grid in the future; and
- Many of New Zealand's energy companies are offering solar and storage products with 400 solar and/or storage installations already installed by Vector Energy.

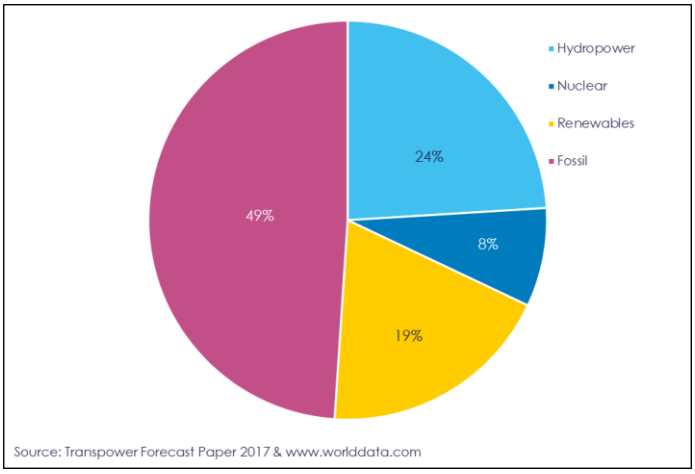


Figure 18 - New Zealand Energy Mix

Main System Players:

The national grid is owned, operated, maintained and developed by Transpower, a state-owned enterprise. There are 29 small distributors or "lines companies" spread over the island maintaining and operating the grid, with 21 of the 29 having less than 50,000 customers and 12 of the 29 in community ownership.

The majority of New Zealand's retail market is served by the retail businesses of the five major gentailers (generator-retailer; Genesis Energy, Contact Energy, Mercury Energy, Meridian Energy and TrustPower). A number of new retailers have commenced operations in New Zealand, reaching 20 in 2016.

In summary:

The main concerns of the NZ system operators are:

- delivering increasing distributed and centralised renewable generation which are seasonal whilst reducing fossil fuel generation; two such resources are (hydro and solar) run counter to energy demand.
- address the three linked issues: the reduction in power system rotational inertia as more wind is connected, the reduced returns from wind due to spill energy and the high cost of alternative flexibility such as pumped storage.

Flexibility services are seen an important tool in the future and are included as an important part of the NZ Roadmap.

Relevant flexibility services Projects:

Project 27 - The NZ Electricity Networks Association

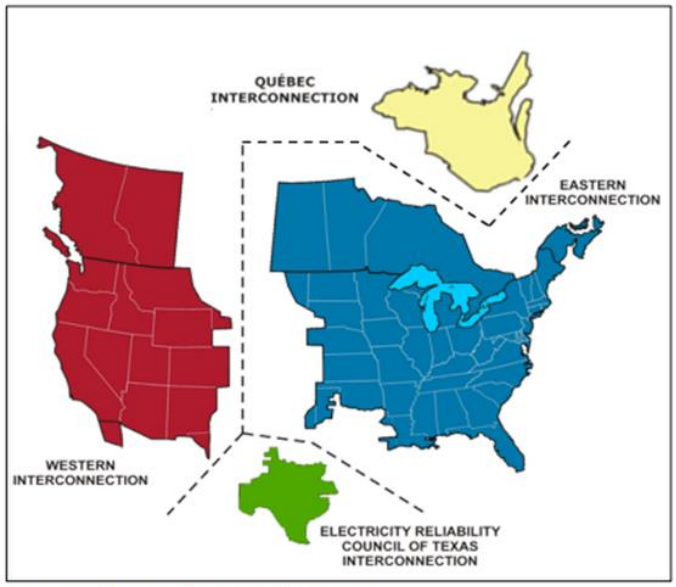
Smart Technology Working Group has set out to develop a network transformation roadmap to enable electricity distribution network businesses to best prepare for the profound change occurring in electricity use and resulting uncertainty. In turn it aims to support consumers with adoption of emerging technology, and to support the New Zealand economy with reliable and renewable electricity.

5.5 The Americas

5.5.1 North America:

The United States is now the second largest user of energy, having recently been passed by China. Fossil generation remains the largest sources of electricity. The United States could be completely self-sufficient of energy.

The electricity grid of the United States is divided into six regions. Two regions (the states of Hawaii and Alaska) operate as independent systems. The other four regions (each comprising smaller grids) are;



Source: North American Electric Reliability Corporation

Figure 19 – US Power Grid

- Eastern Interconnection includes the eastern two-thirds of the continental United States and Canada from the Great Plains to the Eastern Seaboard;
- Western Interconnection includes the western one-third of the continental United States, the Canadian provinces of Alberta and British Columbia, and a portion of Baja California Norte in Mexico;
- Texas Interconnection comprises most of the State of Texas; and
- the Canadian province of Quebec.

These four regions operate collectively to provide stability, reliability and for commercial purposes and have HVDC interconnections for the bulk transfers of electricity and enable generation to provide multiple load centres. This redundancy helps prevent transmission line or generation plant failures from causing interruptions in service to retail customers.

The North American Electric Reliability Corporation, established to ensure the reliability of the North American bulk power system which includes the four regions and enforces mandatory grid reliability standards approved by the Federal Energy Regulatory Commission.[54]

Main Observations:

- Thermal generation (including nuclear) will remain major priorities for the US;
- Shale gas production is on the increase;
- US are still pushing ahead with advance of renewables; and
- Two States are leading on low carbon emission reductions; California and New Jersey.

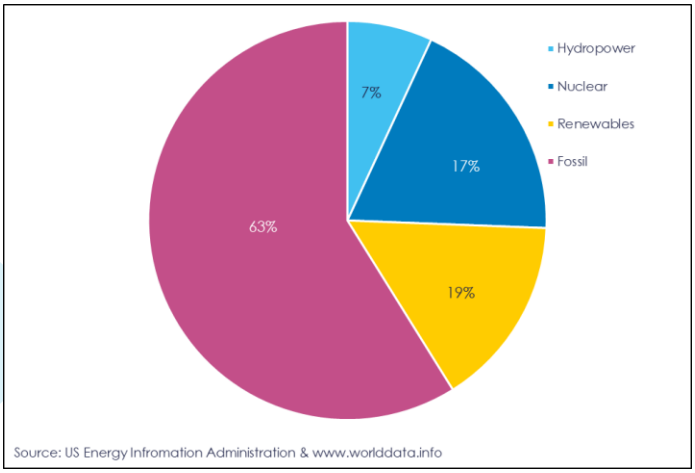


Figure 20 – US Power Grid

Main System Players:

The transmission grid is controlled by seven Independent System Operators (ISOs) and 10 Regional Transmission Organisations (not-for-profit organisations obliged to provide indiscriminate access to suppliers to promote competition).

There are over 3,000 electric utilities in the United States with 2,000 (mostly smaller) utilities engaged only in distribution activities. Of all utilities, 2,020 were publicly owned (including 10 Federal utilities), 932 were rural electric cooperatives, and 243 were investor-owned utilities. [55]

[54] https://www.energy.gov/sites/prod/files/2015/12/f28/united-states-electricity-industry-primer.pdf (section 3.2)

[55] Source: 89 FERC ¶ 61,285 UNITED STATES OF AMERICA FEDERAL ENERGY REGULATORY COMMISSION 18 CFR Part 35

In Summary:

The United States is still a major generator of electricity from fossil fuels, although there is a push for renewables in a few parts of the country.

5.5.1.1 West Coast - California

California's electricity grid increasingly relies on clean sources of energy such as solar, wind, geothermal, hydro, and biomass. As this transition advances, the grid is also expanding to serve new sectors including EVs, rail, space heating and water heating. California has installed more renewable energy than any other U.S. state with 22,250MW of utility-scale generation operational. The state continues to shatter installation records and is home to some of the largest solar, wind, and geothermal power plants in the world.

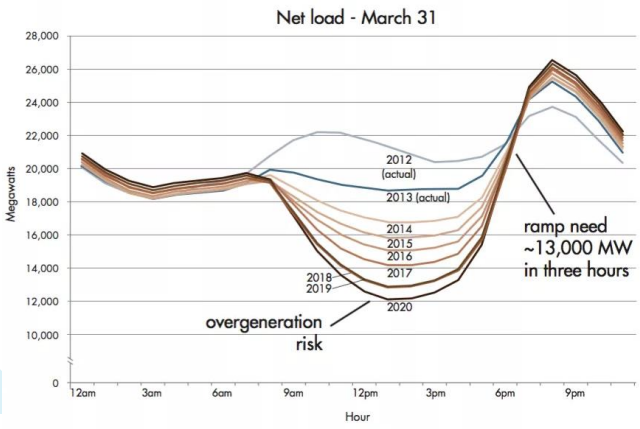


Figure 21 - California ISO Net Load and 3-hour Ramp

The California ISO popularised a graphical depiction of the net load curve (the "duck chart") that dispatchable generating resources must satisfy each hour on a "typical" spring day. The chart underscores the need to fully integrate distributed resources into grid planning and operations to allow maximum use of variable generation.

Initiated in 2014, the Western Energy Imbalance Market is a wholesale energy market that allows participants to buy and sell energy in real-time. Its benefits have grown as more entities join and increase access to more generation and transmission.[56]

Highlights of the Californian Energy Strategy:

- Large scale solar roll out on new homes as part of the 1 million solar roofs initiative and a requirement that all new homes must install sufficient solar to be self-sufficient.

[56] Source: California%20Texas%20resource_flexibility.pdf

- To support continued market growth and make zero-emission vehicles (ZEVs) accessible to more Californians; the state administers programs to offer incentives for the purchase of ZEVs in the light, medium, and heavy-duty sectors. There are many EV projects that have been implemented;[57]
- California has taken bold steps to ensure supply and demand remain in balance as more clean energy resources are added to the grid and this includes integrated resource planning and geographic diversity trading.

Relevant flexibility services projects:

Project 28 - The California ISO – Resource Flexibility

The California ISO believes it needs more operational control than is available through California Public Utilities Commission (CPUC) rules or existing California ISO tariffs. This issue is currently being addressed in the California ISO Flexible Resource Adequacy Criteria Must Offer Obligation (FRACMOO 2) Stakeholder Initiative. This project also includes Texas Wind generation challenge.

5.5.1.2 Texas State

The California ISO is not alone in dealing with renewable resource integration issues. The Texas electric grid operator, the Electric Reliability Council of Texas (ERCOT), wind capacity in Texas has grown by about 17,000MW in the last decade. According to the American Wind Energy Association, as of October 2018 there was more than 23,000MW of wind installed in the ERCOT balancing area, about four times the wind capacity in California.

To integrate this large amount of intermittent generation, Texas also imposed market rules to ensure the stability and reliability of the grid, as well as penalties for non-compliance. ERCOT controls dispatch of the wind resources in real time and uses five-minute wind forecasts so that ERCOT staff can match with loads for ramping and inertia requirements. Also, market prices are used to keep adequate amounts of capacity available for ancillary services and to ensure the ERCOT grid is stable. [58]

[57] Source: 2018IEPR INTEGRATED ENERGY POLICY REPORT UPDATE VOL. 1 CEC-100-2018-001-V1

[58] Source: California%20Texas%20resource_flexibility.pdf

5.5.1.3 East Coast - New York State

New York, the largest of the north eastern states, is dependent on supplies from out of state for more than three-quarters of its energy, New York has developed one of the most energy-efficient state economies in the nation.

Natural gas, nuclear power, and hydro typically provide more than nine-tenths of New York State's net electricity generation; other renewable resources provide most of the rest. Renewable including solar and wind are all on the increase.[59]

New York's state-wide grid is managed by a single independent system operator called the NYISO. The NYISO manages state wholesale electricity markets and transmission.

Relevant flexibility services projects:

Project 29 - DSO Simulation Studio

The electricity industry has identified the formation of Distribution System Operators (DSO) and Distributed System Platform (DSP) as critical to realize faster, tighter and better coordination of DER-based distribution systems, and to provide the necessary market mechanisms to empower consumers, prosumers and DERs to offer and exchange services. DSO/DSP entities are mandated in the New York REV and California proceedings, and are being considered in several other states. Yet, there is no software tool that can simulate DSO physical and market operations.

5.5.2 South America:

5.5.2.1 Brazil

Brazil relies highly on hydro generation capacity, backed up by fossil generation and an increasing percentage of renewables. Hydro generation meets over 70% of its electricity demand. This reliance on abundant hydro, although reduces the overall generation costs does make the country especially vulnerable to supply shortages in low-rainfall years. These droughts and water shortages have increased over the last few years.[60]

[59] Source: eia gov's state analysis

[60] Electricity in the Brazilian Energy Plan PDE 2020

Main Observations:

- All the hydro generation is located far from the main demand areas and Brazil is concentrating on reinforcing internal interconnectors;
- New hydro and thermal generation are planned and renewables (wind, solar and biomass) will see an increase; and
- Very early days in using flexibility services

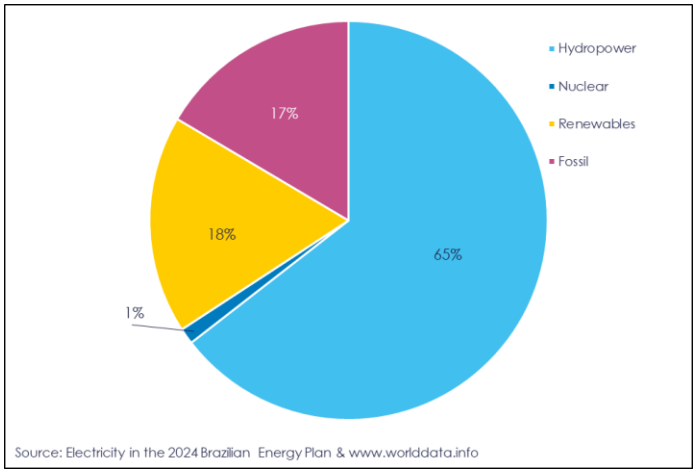


Figure 22 - Brazil Energy Mix

Main System Players:

- ANEEL (Agência Nacional de Energia Elétrica) is the Brazil energy regulator and its function is to regulate and control the generation, transmission and distribution of power in compliance with the existing legislation and with the directives and policies dictated by the Central Government.
- The transmission network has remained almost exclusively under government control through both federal (Eletrobras) and state companies (mainly Sao-Paulo-CTEEP, Minas Gerais-Cemig, and Parana-Copel). It is interesting to note that Italy's ENEL is an active transmission operator on Brazil's National Interconnected System (SIN). Main Transmission Network is under the control the National Electricity System Operator (Operador Nacional do Sistema Elétrico - ONS).
- In Brazil, there are 49 utilities with distribution companies across the country.

In Summary:

Brazil will still rely heavily on Hydropower in the future. We will see new Hydropower plants and thermal plants being built with some renewables coming on stream but still at a low level.[61] Brazil also plan major expansion of their transmission network and substations.

Relevant Flexibility Projects:

No projects were identified at this stage.

[61] Brazil Energy Plan 2024

5.5.2.2 Mexico

Mexico relies on thermal generation for most of its electricity, backed up by hydro generation and increasing amounts of renewables. There is an abundance of natural resources in Mexico, therefore there is now a major move towards more renewable power for the country's needs. Mexico's abundance of renewable energy resource potential, particularly solar and wind, underpins the country's ambitions to decarbonise its energy system.

Main Observations:[62][63]

- 13 interconnectors exist with neighbouring countries including US, Belize and Guatemala;
- Government is pushing for more generation to be build including renewables in the generation mix with a target of 38% of Mexico's generation from clean energy resources by 2030;
- Plans exist to expand transmission network;
- Plans exist to modernise the distribution grids including smart grids;

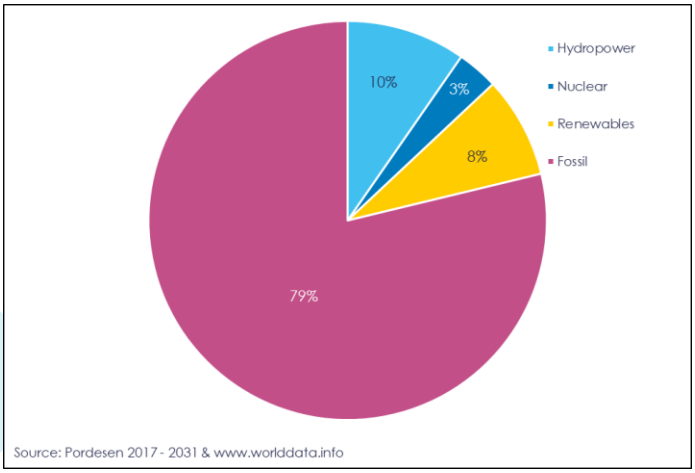


Figure 23 - Mexico Energy Mix

- In 2016, Mexico established wholesale electricity markets that guarantee open and non-discriminatory access to the national transmission grid and distribution grids and regulates the delivery of electricity from power plants to load points. It enables private investment in generation.
- Three long-term auctions for power took place between 2015 and 2017 and awarded contracts for 15 and 20 years for clean energy generation from organisations that included foreign investors. A similar auction planned for December 2018 was cancelled by Government.

[62] National Electric System Development Program (PRODESEN) 2017 - 2031

[63] https://www.nrel.gov.docs/fy19osti/72699.pdf (section 4.3)

Main System Players:

The regulator is CRE whose main tasks are to calculate network tariffs (transmission and distribution), other regulated activities (for example, operation of the basic service suppliers; the electricity system operator CENACE (National Centre for Energy Control)), as well as the final basic supply tariffs.

The entire Mexican transmission and distribution network is owned by CFE. The transmission system is operated by the independent system operator CENACE and the overall electricity system is referred to as the national electricity system. CFE is currently responsible for electricity distribution. There are 16 geographical divisions in charge of distribution.

In Summary:

Mexico benefits from an already well-developed transmission network; however, electricity is transmitted over long distances, which can lead to high thermal losses. Reducing network losses is therefore an important objective for dispatching.

Relevant Flexibility Projects

No projects were identified at this stage.

6. SUMMARY:

Each country was ranked against factors that recognise the role of flexibility in supporting the grids (enabling an increasing penetration of embedded and renewable generation) and the growth in demand (decarbonisation of heating and transport). The factors are;

A. Traditional balancing services (includes interconnectors, hydro and thermal generation);

B. Demand side management (includes energy efficiency, demand side response and energy storage);

C. Committed to flexibility investment in innovation and trials; Government and/or regulator support;

D. Existing flexibility pilot projects; and

E. Flexibility services as Business as Usual.

Each factor was scored between 0 (no evidence) and 10 (evidence) and then aggregated to determine a total ranking score. The results of this analysis are summarised in Table 3 below:

Table 3 - Scoring Matrix

Country	A	B	C	D	E	Aggregate	Comments
Europe							
Italy	10	7	8	5	0	30	USED - A, B, C, D
France	10	6	7	6	0	29	USED - A, B, C, D
Germany	10	7	7	7	0	31	USED - A, B, C, D
Spain	10	6	8	6	0	30	USED - A, B, C, D
Netherlands	10	6	8	7	0	31	USED - A, B, C, D
Norway	10	7	5	4	0	26	USED - A, B, C, D
Sweden	10	7	5	4	0	26	USED - A, B, C, D
Great Britain	10	6	8	8	4	36	USED - A, B, C, D, E (CMZ & ANM)
Asia							
Japan	10	3	8	5	0	26	USED - A, B, C, D; Emergency - Storage & VPP
China	10	3	9	5	0	27	USED - A, B, C, D
South Korea	10	4	8	5	0	27	USED - A, B, C, D; Blockchain
Oceania							
Australia	10	6	6	6	5	33	USED - A, B, C, D; Network Storage
New Zealand	10	5	6	6	2	29	USED - A, B, C, D
North America							
California	10	7	8	6	5	36	USED - A, B, C, D, E; New Flexibility Markets
Texas	10	5	8	5	4	32	USED - A, B, C, D, E; Storage for Renewables
New York	10	5	8	6	2	31	USED - A, B, C, D; ANM
South America							
Brazil	10	5	2	2	0	19	USED - A, B, C, D
Mexico	10	4	3	2	0	19	USED - A, B, C, D

7. CONCLUSIONS:

This report has considered flexibility programs in 18 countries across the world. The methodology employed involved desktop research and analysis of a variety of literature sources, including; discrete research reports, government research papers, government policies, reports on flexibility projects and news articles. The information available for countries varied considerably as did the information for flexibility project reports which limited their usefulness due to one or more of the following; poor expression of all findings, visibility of the data or the reporting of learnings (and, importantly, the failures). In general, the report should be considered as a snapshot of this area as at the end of March 2019. The analysis will support the work to be undertaken by TRANSITION teams in other work packages.

The 18 countries were selected based on a widely reported aspiration of reducing fossil fuels in their generation mix and an increase in renewable generation technologies, making them ideal candidates for the early adoption of flexibility services. The report considered their energy mix, the growth of renewables, the availability of demand response, the availability of energy storage, the growth of electric vehicles and, the use of flexibility services.

The top four scoring countries included California, GB, Australia and Texas and all scored high due to their commitment to innovative projects and their growing acceptance of flexibility services as a business as usual solutions.

The report highlights a further 25 additional relevant projects, in addition to FUSION and EFFS, and the ENA's Open Networks project, worth considering for further reference for project TRANSITION. These projects cover a range of studies into the value of flexibility and cover areas such as: maximising the roles of DSOs and TSOs, developing new flexibility market models, creating virtual power plants, managing grid constraints and cover a range of assets including demand response, electric vehicle incl. vehicle to grid, generators, and energy storage. The projects also cover subjects such as blockchain and energy efficiency.

The top six flexibility projects recommended for further reference, due to their inclusion of new flexible market development work and trials with the DSOs are shown below on Table 4.

Table 4 - Recommended Projects

Project Name	Country	DSO	Summary /Highlights	Additional Info
1. EU-SysFlex	Pan-European	Various	Coordinated use of flexibility for large scale integration of Renewable Energy Systems	Reports available now – Project due to finish 2020
6. Interflex	Various	Various	Explores pathways to adapt and modernise the distribution network consistent with the 2020 and 2030 climate-energy objectives of the EC.	Started 2017 and is a 3-year project
7. Enera	Various	TenneT, Avacon Netz and EWE NETZ	A multi-organisation project funded by the German Ministry of Economics and Energy that aims to develop and demonstrate scalable solutions for energy transition in networks, market and data using a flexibility platform.	Uses USEF; completed 2018; now in demonstration mode
11. Dynamo Functional Flexible Market	Netherlands	Liander	DYNAMO is establishing a USEF-based functional flexibility market to solve real-life problems. It has three active locations.	On-going
13. Smart Solar Charging	Utrecht, Netherlands	Stedin	DSO can call use flexibility via an aggregator during periods of congestion (high solar production and low demand) and during high market prices.	Uses USEF; 3-year project started 2017
25. Ausgrid Power2U	Sidney	Ausgrid	VPP - by permanently reducing customer demand for grid supplied electricity, Ausgrid can delay, or avoid, network investment and, over time, lower the cost of electricity for all customers.	Currently at tender stage for participants. On-going

The following summarises the main findings,

- The journey to transition from fossil fuel to renewables generation is on the increase worldwide;
- Demand Response and energy efficiency is on the increase;
- Electric Vehicles are on the increase;
- GB and Europe have the most flexibility services projects.

The analysis indicates a widespread increase in renewable generation across the world. There is still a general concern that the intermittency of renewable generation will affect the ability to balance the transmission and distribution grids to keep the lights on, although the experience from Texas provides some comfort in this area.

There is a general agreement that "new" flexibility services models and marketplaces will offer more than the traditional balancing systems, and that the transmission and distribution companies will have to be more proactive in managing the two-way flows of electricity to maximise the benefits from a low carbon future.

GB and Europe have invested the most into research and development of flexibility services, with the two coast states in America having the greatest aspirations to meet their emission targets. Australia and New Zealand are moving fast with batteries and demand response for reasons of network security. Asia is currently lagging, but they have plans for massive investment in this area, and will, undoubtedly catch up fast.

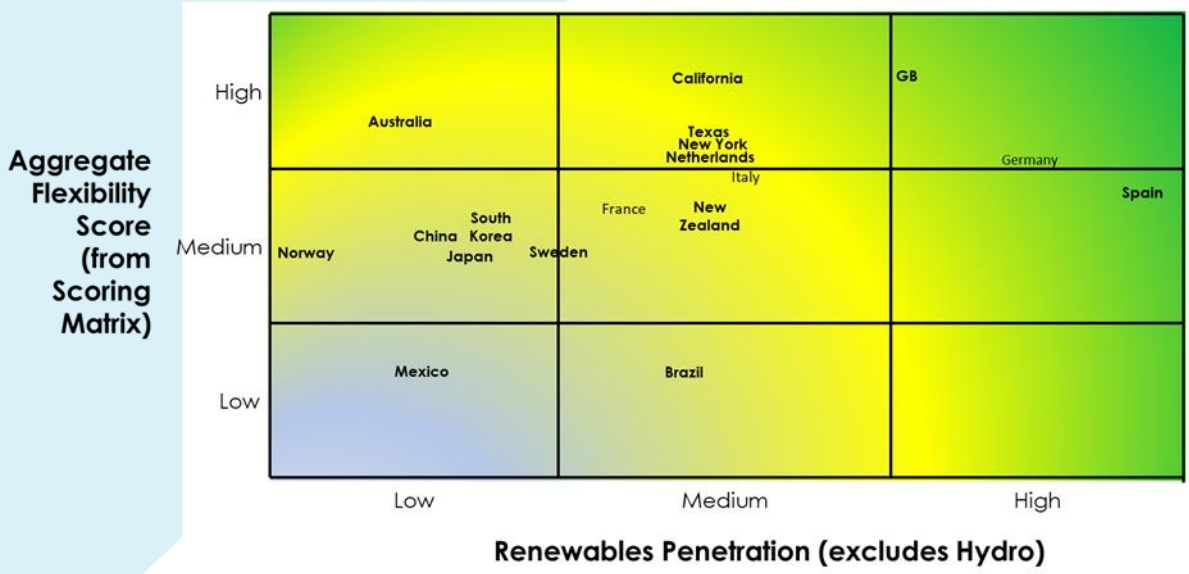


Figure 24 – Summary of International Flexibility Opportunities

Figure 24 highlights those countries which have or are rolling out renewable generation with Spain, Germany, and GB leading the way. It should be noted that Norway is an anomaly as it already generates over 90% of its needs from hydro which has been excluded from the analysis.

Although the Asian countries are currently lagging, it is expected they will catch up and overtake Europe through their respective Governments' proposed committed investments towards renewables and in developing their smart grid.

In North America, the coastal states are leading the way with demand side management and flexibility services already being used as business as usual as they have been promoting low carbon energy for many years.

Oceania countries are in the middle. South Australia is very active in demand response and renewable generation, but the country is still reliant on fossil generation. New Zealand has very big aspirations in reducing their need for thermal generation and promoting flexibility services.

South American countries are coming to market with some big plans to reduce their dependence of thermal generation and moving to renewables. Both Brazil and Mexico have an abundance of natural resources, although Brazil (heavily reliant on hydro generation) is seeing regular droughts and shortages of water are now recognised as a reason to diversify for their future.

The analysis indicates that grids across the world still rely on traditional balancing services and that flexibility services are in their infancy.

Figure

8 ADDITIONAL PROJECTS

1 **H2020-EU.3.3.4**. Program: **EU-SysFlex -** Pan-European system with an efficient coordinated use of flexibilities for the integration of a large share of Renewable Energy Systems;

2 **FLEXCoop i**ntroduces an end-to-end Automated Demand Response Optimization Framework. It enables the realization of novel business models, allowing energy cooperatives to introduce themselves in energy markets under the role of an aggregator.

3 **REFLEX** – Analysis of the European energy system under the aspects of flexibility and technological progress. It is thus the core objective of REFLEX to analyse and evaluate the development towards a low-carbon energy system with focus on flexibility options in the EU to support the implementation of the SET-Plan.

4 **Magnitude** – Bringing Flexibility provided by multi energy carrier integration to a new MAGNITUDE Project ID: 774309 Magnitude addresses the challenge to rise flexibility in electricity systems.

5 **ENERGY.2010.7.1-1** - Large-scale demonstration of smart electricity distribution networks with distributed generation and active customer participation. The Nice Grid project is one of six smart grid demonstrations within the large-scale Grid4EU project.

6 **InterFlex**: Flexibility in Action - In InterFlex explores pathways to adapt and modernize the electric distribution system in line with the objectives of the 2020 and 2030 climate-energy packages of the European Commission. European Union's Horizon 2020 research and innovation programme under grant agreement n°731289

7 **ENERA:** USEF Demonstration of scaleable solutions. A multiple organisation consortium project funded by the Federal German Ministry of Economics and Energy. Using USEF It aims to develop and demonstrate scalable solutions for energy transition in three areas: grid, market and data using a flexibility platform.

8 **TenneT Cooperation Project Grid Stabilization - Vehicle 2 Grid:** In spring 2018, TenneT, the energy service provider The Mobility House and the automobile manufacturer Nissan launched a joint pilot project to investigate whether electric cars can contribute to solving this problem. In addition, proposals for regulatory guidelines for the "Vehicle-to-Grid" concept will be developed and evaluated.

9 **GO15. Reliable and Sustainable Power Grids:** GO15 is a voluntary initiative of the world's 16 largest Power Grid Operators, with the aim of leading the transition to the future power grid. The objective of DSM (Demand Side Management) is to maximize the efficiency of the electric grid by enabling end-users to base usage decisions not only on their value of electricity but also on actual grid conditions.

10 **Hoog Dalem:** (USEF) Home Battery Systems

11 **DYNAMO:** (USEF) Functional Flexible Market and is establishing a USEF-based functional flexibility market to solve real-life problems. It has three active locations.

12 **ENERIEKOPLOPERS:** (USEF) Smart Energy use decreases power outages. Unlocking flexibility from local power consumers. A USEF-based smart energy system connects 200 households in Heerhugowaard and predicts the daily electricity use and production.

13 **Smart Solar Charging:** DSO, will be able to call on surplus energy via an aggregator during periods of high solar production and low demand, in periods of congestion or high market prices.

14 **Project FUSION:** This project will trial commoditised local demand-side flexibility through a structured and competitive market-based framework, enabling the DNO and all market actors to unlock the value of local network flexibility.

15 **Project EFFS:** The project will deliver a practical robust and accurate system capability that will enable a DNO to actively manage the provision of flexibility services necessary for transition to becoming a DSO.

16 **ENA Open Networks Project:** Is one of the largest energy industry initiative that will transform the way our energy networks work, underpinning the delivery of the smart grid. This project brings together 9 of UK and Ireland's electricity grid operators, respected academics, NGOs, Government departments and the energy regulator Ofgem.

17 **Gridshare roll out of flexibility with ITOCHI:** Moixa has been working closely with ITOCHU to integrate their customer on-boarding process to the GridShare platform, enabling efficiencies in managing the life cycle of customers, designing and automating processes and increasing visibility of customer status.

18 **VPP: In Japan, Tepco and Kansai Electric Power Co**. are working together with Nissan Motor Co. to test virtual plants, while a similar alliance exists involving Chubu Electric Power Co. and Toyota Motor Corp.

19 **Conjoule - Peer to Peer Trading: Tokyo Electric Power Company Holdings Inc**. started a project to set up a peer-to-peer electricity trading platform together with German power firm Innogy SE. The platform allows participating individuals to directly sell their surplus solar power to local supermarkets and companies via transactions using smartphones. The service is slated to begin in Germany as early as this month.

20 Virtual Power Plant Construction and Demonstration Project (release from Kansai Electric Power Co., Inc.) **http://www.kepco.co.jp/corporate/pr/2016/0728_3j.html**

21 **Project Artemis: GridWiz / Electron:** This project will pilot an energy flexibility trading platform in South Korea. The partners will collaborate to research, design and test energy

flexibility products for the South Korean electricity market. Building upon Electron's existing flexibility trading platform, the project aims to assist the development of a marketplace.

22 **KEPCO: various Smart/ Micro Grids projects:** incl. Frequency Regulation; Gasa Island Micro Grid; Gapa Island Micro Grid; Smart Demonstrator Jeju Island.

23 **Chargefox Electric Vehicle:** Chargefox network of ultra-rapid charging stations will play a significant part in improving Australia's infrastructure and remove one of the major barriers that limits the adoption of electric vehicles (EVs).

24 **Australian Electricity Network Association:** Transformation Roadmap publications can be downloaded from www.energynetworks.com.au/electricity-network-transformation-roadmap

25 **Ausgrid Power2U Project:** The Ausgrid Power2U project involves the establishment a $4.1 million fund to help selected customers to permanently reduce their electricity use on Ausgrid's network. By permanently reducing customer demand for grid supplied electricity, Ausgrid can delay, or avoid, network investment and, over time, lower the cost of electricity for all customers.

26 **Tempus Energy & Origin Energy**: Trial demand management in South Australia, Tempus is partnering with Origin to pilot flexible energy demand management in South Australia.

27 **The NZ Electricity Networks Association**: Smart Technology Working Group has set out to develop a network transformation roadmap to enable electricity distribution network businesses to best prepare for the profound change occurring in electricity use and resulting uncertainty.

28 **The California ISO – Resource Flexibility:** believes it needs more operational control than is available through California Public Utilities Commission (CPUC) rules or existing California ISO tariffs. This issue is currently being addressed in the California ISO Flexible Resource Adequacy Criteria Must Offer Obligation (FRACMOO 2) Stakeholder Initiative. This project also includes Texas Wind generation challenge.

29 **DSO Simulation Studio New York State:** The electricity industry has identified the formation of DSOs and Distributed System Platform (DSP) as critical to realize faster, tighter and better coordination of DER-based distribution systems, and to provide the necessary market mechanisms to empower consumers, prosumers and DERs to offer and exchange services.

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TRANSITION
Analysis of relevant international experience of DSO flexibility markets
22 August 2019

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